THE

PRINCIPLES AND PRACTICE

OF

SURGERY,

BEING

A TREATISE ON SURGICAL DISEASES AND INJURIES.

BY

D. HAYES AGNEW, M.D., LL.D.,
PROFESSOR OF SURGERY IN THE MEDICAL DEPARTMENT OF THE UNIVERSITY OF PENNSYLVANIA.

PROFUSELY ILLUSTRATED.

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PREFACE.

The present volume is the first part of a work on the "Principles and Practice of Surgery."

For a quarter of a century I have been unceasingly occupied with the study of anatomy and surgery, and during most of that time have been actively engaged, as a public instructor, in communicating the great teachings of these closely-allied branches, in the hospitals of Philadelphia and in the halls of the University of Pennsylvania, to thousands of young men from all parts of the United States and to many from foreign countries.

Most of the pages have been written, not in what may be termed moments of leisure, but during the hours of the night,—hours stolen from the time usually allotted to the repose of body and mind, and after the daily labors of an exacting public and private practice.

In the composition of its pages, while I have expressed my own views independently on all subjects, I have also endeavored, as far as was consistent with the scope and limits of the work, to record those of other writers, not only that the student and the practitioner may be made familiar with the literature of their profession, but also that they may be able in their observation and practice to contrast different plans of treatment, and in this way draw their own conclusions in regard to the relative merits of the various modes of managing surgical disease. Whatever may be the defects of the work,—and none can be more sensible of these than myself,—I have endeavored most conscientiously to furnish a safe and reliable guide for the surgical practitioner.

To Drs. Willard, Hunter, White, Muhlenberg, Haynes, Alison, Griffiths, Abel, and others, I am under obligations for valuable assistance rendered me in the collection of statistical information, and to Drs. Willard and White for a careful revision of the proof-sheets while the work was passing through the press, and for the preparation of the index.

I have also to acknowledge the kindness of the Surgeon-General of the United States Army in allowing me the use of a number of wood-cuts.

A large number of the illustrations have been executed from original drawings by Mr. Faber, while those which have been used from other writers I have, whenever able, referred to their proper source. I am also indebted to Mr. Gemrig and Mr. Kolbe, surgical cutlers of Philadelphia, for many cuts of instruments and other surgical appliances.

D. HAYES AGNEW.

1611 Chestnut Street, Philadelphia.

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INTRODUCTION.

SURGICAL DIAGNOSIS.

That is an exceedingly crude and erroneous conception which regards surgery as a mere handicraft, or as an art restricted to the treatment of external disease. It will never be possible to draw the lines which separate this department of scientific knowledge from that of medicine: the two are indissolubly one, and all attempts to divorce them detract from both the dignity and the power of the surgeon.

The successful management of disease presupposes its distinct recognition. Without such antecedent knowledge the practitioner is not only incompetent to administer to the necessities of his patient, but is also liable to commit irreparable mischief. To determine with certainty the nature of a malady by stripping away all disguises, involves in many instances well-trained habits of observation and an enlightened judgment. It is my design, therefore, before entering specifically upon this work, to devote a few pages to the subject of surgical diagnosis.

Anatomy, physiology, pathology, organic chemistry, and physics form the ground-work of diagnosis. For the proper interpretation of morbid phenomena the senses must be carefully educated and the mind trained to precise logical methods of thought. There is a very great difference in the rapidity with which different men, of unquestioned surgical ability, form their judgments on the nature of disease or injury. There are some who reach their conclusions with a celerity which resembles more an intuition than an orderly process of deductive reasoning; while others pass over the same ground like the prudent general who fortifies every captured post as he advances into the enemy's country. On the whole, the latter are those who meet with the fewest defeats. The nature of many affections is so obvious that recognition is possible on the instant; but there are other maladies, and perhaps a larger number, which demand for their comprehension the most careful and exhaustive investigation. As the issues of life and death are often suspended on the decision arrived at by such inquiries, it becomes every surgeon to feel the solemnity and the responsibility of his work.

A third class of cases will be encountered, so obscure and unpronounced as to baffle the keenest analysis. Whenever, therefore, the surgeon is compelled to proceed on a data of probabilities, it is in most instances a good rule to *wait*. Often in my professional life, when in a maze of doubt and uncertainty, have I imitated with the happiest results the storm-bested mariner, who, in the darkness of the night, and nearing an unknown coast, casts anchor and waits for the day. A few hours even of delay may open a crevice in a hitherto hidden case of disease, which will be sufficient to illuminate its obscurity and resolve all uncertainties.

The difficulties which are encountered in the investigation of morbid phenomena arise from several causes. First, there is on the part of many persons a disinclination to communicate information which would appear in any way to reflect on the moral or social character of themselves or their

families, and hence they will deliberately withhold testimony which is necessary to the proper understanding of their disease. Secondly, many affections diverse in nature present phenomena having common points of resemblance. Thirdly, there is an individual peculiarity or idiosyncrasy, that is, some peculiar stamp of organization which renders its possessor, in his or her susceptibility to, or behavior under, morbid impressions, unlike the majority of other persons under the influence of similar causes. And, fourthly, there exists the power of reflex and sympathetic action dependent on physiological and anatomical peculiarities of structure, to mask, or to divert attention from, the real seat of trouble.

There are two factors concerned in forming a diagnosis,—the *senses* and the *reason*, or the physical and the rational. By the first the mind receives those impressions which, being compared and classified, are compacted into a judgment or an opinion.

There are two modes of investigating disease, namely, by analysis and by synthesis. In the first, our inquiries commence at the beginning of the affection, thence following it down to the time of examination; in the second method the order is reversed, the disease being traced back to its origin. The first or analytical process is generally adopted, though it will often be found necessary to use the other, or synthetical, plan. Whichever course is pursued, the certitude of a conclusion in many cases can only be attained by elimination, that is, by systematically excluding the diseases which most closely resemble the one under consideration, thereby proving what it is by demonstrating what it is not. Generally speaking, it is preferable, in instituting an inquiry with a view to discover the character of a complaint, to begin with the general history of the case, and afterwards to take up its particular characteristics. This course has the twofold advantage of being the most natural method of procedure and of establishing confidential and pleasant relations between the practitioner and his patient. To secure the last is of the utmost importance to the success of the examination.

Some men are singularly unfortunate in this respect: they are never able to secure the confidence of the sick; while others, by a cheerful manner, by a few kind, assuring words, and by an attractive address, obtain in a few moments a magnetic mastery over their patients. In pursuing the examination the patient may, if intelligent, be allowed to give his or her own history of the disease, but should be kept closely to the subject, and all digressions should be discountenanced. There is much skill in questioning. The interrogations should be put in plain, simple words, free from ambiguity and technicalities, and the answers required should be terse. No suggestive or leading questions ought to be asked, as these tend to give color to the answers. Everything like levity of manner or merriment at the language used by patients is improper, if not cruel. No interrogation should be made merely from motives of curiosity, and such as are of a private nature should be couched in the most delicate and least offensive phraseology. Many questions of this nature, when the patient is a young woman, are best addressed through a female friend. In the examination of females, except when absolutely necessary, no part of the body should be uncovered. No needless repetition of instrumental explorations, or of painful movements, is justifiable. The surgeon must not forget the moral transformations of character wrought by disease, by which the most amiable and self-possessed become peevish, morose, and irritable; and he must make due allowance for deportment which under other circumstances would be properly esteemed rude and uncivil. He must also assure, by a conciliatory and encouraging manner, the unlettered, who, from want of training in the use of language and in the command of words, are unable fittingly to communicate their sensations. Under all circumstances of intercourse with the sick and injured, let the surgeon never forget that being himself human, and therefore liable to be overtaken by the same diseases, the same accidents, and the same misfortunes as the humblest of his fellow-beings, he should be ready to compassionate and to sympathize with them in their distresses, in

their infirmities, and in their mental eccentricities. Especially have the poor the strongest claims to our consideration. To be sick is ordinarily esteemed a misfortune, but to be both poor and sick, is a trial to the spirit of no ordinary kind.

In the investigation of a surgical disease there are two lines of inquiry to be pursued,—the *general* and the *special*. The first, or general, consists in eliciting a historical narrative from the patient or his friends, with reference to his past life and the disease under which he labors. Under the first inquiry will come the age, sex, occupation, habits, mental and moral states, antecedents, social condition, residence, information derived from others, and duration. Under the second will be included the testimony of the senses.

Age.—The age of a patient has a most important bearing on the examination of a case of disease. In the very young the exalted sensibility of the nervous system imparts a peculiar complexion to many of the affections of infantile life. Thus, the mere irritation of the gum in dentition or of a narrow prepuce is sufficient, through reflex irritability, to excite the most violent spasmodic agitation of the entire muscular system. It is also during the period of infantile and adolescent life that those morbid phenomena which are comprised under the generic term struma, or scrofula, make their appearance. A tumor in the neck of a child suggests at once an adenoid growth or an angeioma. A pain at the knee, accompanied with slight lameness, arouses a suspicion that the case is one of coxalgia. In adults, or in advanced life, the cervical enlargement would probably be either cystic, fatty, or sarcomatous, whilst pain and lameness, complained of in the lower extremity, would be referred to a rheumatic origin. Abdominal pains in a child, a disturbed, grunting respiration, and unusual postures of the body for rest after taking exercise, would suggest the probability of spinal disease. A spreading ulcer on the oral surface of the cheek of a young person would be diagnosed as noma or cancrum oris, while similarly situated in an adult it would probably prove to be a malignant affection.

Again, force applied near to the extremities of a long bone in a youth is liable to cause a separation of the epiphysis,—an accident which would be impossible in an adult. A blow which in mature life causes a fracture through the shaft of the femur, would, in an aged person, most likely result in an intra-capsular fracture. Irritation of the bladder in a young subject would be referred to the presence of calculus or to a tight phimosis; but in an adult, or in a person over fifty, the investigation would have to include the consideration not only of stone, but also of stricture, cystitis, hypertrophy of the prostate body, and hemorrhoids,—diseases which more especially belong to mature and advanced life.

Sex.—The influence of sex exercises both a determining and a modifying influence on morbid processes. There exists a radical difference, both psychical and physical, between the male and the female, and no amount of training, under the modern interpretation of the equality of the sexes, can ever remove this distinction without at the same time destroying the true grace and dignity of the female character. The sexual system of woman, reacting upon a susceptible organization, imparts a shading to most of her diseases. The perturbating influence arising from commencing menstruation and its disappearance, is exhibited in peculiar derangements of the nervous and muscular systems. Thus, we have convulsions, hysterical joints, hysterical blindness, spurious paralysis, irritable bladder, and, farther on towards the climacteric decline, fibroid and carcinomatous growths of the uterus and of the mammæ.

Males, on the contrary, enjoy a remarkable immunity from these affections. Among them, hysterical disturbances are comparatively unknown. If a male suffer from cancer, it is generally of the epithelial form, and on the lip; if from articular disease, it will not be a simulation, but a genuine inflammatory attack, rheumatic or otherwise; if attacked by convulsions, they

will usually be epileptic, and indicative of serious cerebral disease; if overtaken by paralysis, the brain or the spinal marrow will probably be found to have suffered some lesion; if vesical trouble is experienced, the symptoms will depend as a rule on structural, not on functional, changes.

Both sexes are liable to hernia; but femoral rupture is most common in females, and inguinal in males. Disorders of the heart and blood-vessels are common in both men and women. In the former they are often the expressions of atheroma, aneurism, or valvular disease; in the latter they are generally the result of transmitted irritation.

The predominance of the functional and the emotional in females should, however, never be allowed to betray the surgeon into error, by causing him to relax the vigilance of his watch for the real disease, or by inducing him to form hasty conclusions. Through mistakes of this kind many women have suffered long, and at length have fallen victims to maladies which, had they been early recognized, might have been cured.

Occupation exercises no small degree of influence in predisposing persons to certain diseases. Examples of this are seen in the enlargement of the bursa in front of the patella, commonly called "*housemaid's knee*," and in the little bursal tumors which form over the olecranon processes of the ulna in the school-boy who rests upon the points of his elbows.

Persons who are obliged in the prosecution of their business to work in damp or wet localities frequently suffer from rheumatic and bone affections. Occupations or trades which expose the operators to gaseous emanations furnish examples of disease. In this way are produced necrosis of the jaw and stomatitis from the vapors of phosphorus and mercury. In callings demanding great muscular strain, the predisposition to aneurism and to cardiac disorder is marked; and it is to be feared that some of the popular amusements of the day, such as boat-racing and gymnastics, contribute to the same result. Carters, stevedores, and laborers, who, from the nature of their avocations, are often led to consume large quantities of stimulants, are prone to attacks of delirium tremens on the reception of any severe injury. This is often witnessed in our hospitals among patients who have met with fractures.

Another familiar illustration of the effect of occupation in the production of disease is the soot-cancer which attacks the scrotum of chimney-sweeps.

The employment of individuals should not escape our notice in those instances of spinal curvature, or of loss in the bilateral symmetry of the limbs, which are occasionally encountered, and which, without some explanation of this kind, would constitute a source of much anxiety. A man constantly working a foot-lathe or a single-handed lever will, by his business, materially modify the nutrition, and consequently the size, of the limb used in driving such instrument. The shoemaker also who, while at his bench, constantly bends over his work, will in time change the curves of his spine and the conformation of his chest.

Habits.—Many of the ailments which overtake individuals are self-inflicted. They follow as a consequence of pernicious habits, and a knowledge of these at once discloses the true character of many morbid phenomena. Thus, a sore on the prepuce or on the glans penis, if known to follow impure connection, will at once be pronounced a chancre: if a patient presents himself with purulent urethritis, the confession of a previous intercourse with a "woman of the town" will determine its probable character. A virtuous and pure-minded young woman, or an innocent nurse, may present symptoms of such a character as would seem to challenge her personal purity; but if it can be ascertained that the lover of the first suffered from a syphilitic crack or ulcer of the lip, or that the infant which nursed from the breast of the last came into the world with a hereditary taint, we can perfectly comprehend how the presence of this loathsome curse may be entirely consistent with the innocence of its victim.

So in regard to sexual weakness, or to impotency, both the diagnosis and

the prognosis will be materially assisted by ascertaining that the loss of power is the effect of venereal excess.

An ophthalmologist, in certain obscurations of the vision which result from the excessive use of tobacco, would give a most unfavorable prognosis did he not learn that the patient was an inveterate smoker.

Mental and moral states.—The power of the mind and of the emotions over the organic functions of the body is generally conceded, but that it is a more common factor in the production of disease than is generally allowed I doubt not. Many times have I witnessed instances of irritable bladder accompanied by turbid urine following the simple harass and worry of mercantile and other business complications. I have seen almost complete suppression of the urinary secretion continue for days in a person who, in a state of intense anxiety, watched by the bedside of a sick friend. A heart-murmur may be developed in a moment under the urgency of a strong mental shock, and as suddenly may the secretion of any of the different glandular organs be suspended by fright. The depressing effect of mortification, remorse, fear, and frustrated plans upon the vital energies of the body is always inimical to the work of repair after surgical injuries.

On the other hand, there are those who, from possessing an undue exaltation of the imagination, conjoined with an ardent temperament, are prone to give an exaggerated and unreal coloring to their complaints, which might lead the practitioner into error were he not apprised of this peculiarity.

To inspire faith, hope, and courage in the minds of the despondent sick is one of the highest duties of the physician, and will in many instances work greater marvels than can be obtained from drugs.

Antecedent history.—This includes a knowledge of both ancestral and personal constitutional characteristics. It is not always easy to elicit reliable statements on these points. Many persons are peculiarly sensitive about what may be called the physical defects of their ancestors, and purposely withhold the knowledge which they possess. No fact, however, is better established in medicine than the transmissibility of bodily infirmities, and in obscure cases of pulmonary disease, or in tumors whose characters are not well pronounced, in articular affections and in manifestations resembling syphilis, such knowledge is of the highest moment in forming a correct diagnosis, and also in adopting a proper line of treatment. If the case under consideration is one in which, without any positive detectable lesion, there are indications of a tubercular disease, in consequence of the unpronounced nature of the symptoms the physician may hesitate about advising an immediate removal to a more congenial climate; but if told that a paternal or maternal progenitor of the patient died from consumption of the lungs, his decision is formed without hesitation. In the same way will he decide on the nature of a morbid growth, on coxalgia, and on other diseases, by the antecedents of the patient.

In pursuing this inquiry it must be remembered that transmissible diseases sometimes pass over one generation, so that the stream will occasionally require to be traced to the grandfather or the grandmother before the fountain which has tainted the blood is reached.

The individual or personal history comprises a knowledge of the constitutional bent, impress, or temperament. With some persons the vascular system is highly developed, as manifested by a strong, vigorous heart, a bounding pulse, an active capillary circulation, a florid color, and an habitual warmth of the surface. These indicate a *sanguine temperament*, and its possessor is thereby predisposed to acute inflammatory disease of different organs. The surgeon, aware of such tendencies, must be ever on the alert, during the progress of any case of disease or injury under his care, for the earliest evidence of such complications. In other instances there will be seen persons in whom the circulation is sluggish, the complexion dark, the sensibility obtuse, and in whom the mental operations and the movements of body are conducted with slowness and deliberation. These are the leading characteristics of

the *phlegmatic temperament.* Individuals having such an organization endure without complaint, suffer with a certain stolid indifference, and rarely betray by their manner what is going on, either in the mind or in the body. Here the practitioner may be led into a false security, little comprehending the mighty currents of mischief which may be flowing beneath a calm, unruffled surface.

The *nervous temperament* crops out in irrepressible and restless action, a circulation stirred into activity on the presence of the slightest indisposition or accident, and whose demonstrations of uneasiness and suffering always appear to be extravagant or disproportionate to the extent or degree of the injury incurred. Here it will be necessary to make a reasonable allowance for the excessive exhibition of nervous sensibility.

It is not always that these temperaments are as distinctly defined in nature as the portraits which have been drawn. Sometimes they are blended so that the same individual will exhibit the lineaments of two or more.

Social condition.—It is often desirable to know the social state of a patient, whether married or single. Inquiries under this head would include sexual indulgences,—lawful and illicit,—number of pregnancies, miscarriages, puerperal complications and accidents, and the existence of any venereal disease.

Residence.—Surgical diseases are often modified by local influences, a knowledge of which should always, if possible, be obtained. The constitutional changes induced by exposure in miasmatic districts at some recent or remote time will often manifest themselves in the form of an intermittent, or in an enlarged spleen or liver, in the course of a surgical malady. The anxiety following the occurrence of a rigor after some grave operation will be materially lessened if it is ascertained that the patient has been exposed to those conditions of heat and moisture which are associated with miasmatic emanations. The character of disease as it appears in that class of a metropolitan population which live in damp cellars, scarcely illumined by a single ray of sunshine, and who in addition subsist on articles of food defective in quality and in preparation, is very unlike that which occurs under opposite hygienic conditions.

Personal knowledge of patient by others.—The diagnosis of a disease is often established by a knowledge of the determining cause. This information the patient, if disposed, can frequently communicate, or it may be obtained from a friend or some eye-witness. If a joint becomes suddenly swollen and painful, and we are informed that this condition followed immediately on the reception of a sprain, the diagnosis is clear; in the absence of such a history it might with equal propriety be referred to a rheumatic cause. If it is known that a person suffering from epilepsy had, previous to the appearance of a convulsion, received a severe blow upon the head, this fact would not only serve to fix the traumatic origin of the disease, but also to determine under certain circumstances the propriety of an operation. A man picked up in a state of profound coma, especially if the smell of liquor can be detected on his person, might be supposed to suffer only from extreme intoxication; but if a bystander can testify to a fall from a window or from a horse, in which the patient struck upon his head, the diagnosis will be corrected. A laborer was carried from the highway into an adjoining house in a state of collapse, and died shortly after. There was not a mark of violence upon his body. Only a few minutes before, he had left his home in perfect health. It is doubtful if even a post-mortem examination, had it been made, would have solved the mystery which enshrouded his death. It was, however, afterwards ascertained that he had been thrown violently upon his abdomen against a projecting mass of stone by a runaway horse. Without this information all opinion as to the nature of the injury would have been purely hypothetical. Facial paralysis is not unfrequently the effect of a blow below the ear; the gravity of the case will be lessened by a knowledge of such an injury. In hydrophobia, in certain specific ulcers, in phosphorus-necrosis, in incipient coxalgia, in some instances of mental aberration, and in many other affections which will naturally occur to every practitioner,

the statements of the patient or of others constitute a valuable auxiliary to diagnosis.

Duration.—The length of time for which a swelling or tumor has existed is usually deemed a matter of considerable moment in determining one of the first questions presented to the surgeon for his decision, viz., is the growth malignant or not? Cancer and allied tumors are, for the most part, rapid in their increase, while those which pursue a chronic course are generally benign. Too much importance, however, must not be attached to the duration alone of a disease, as there are many exceptions to the rule that malignancy and rapidity of growth are unvarying associates, or that chronicity and harmlessness are always found together.

KNOWLEDGE ACQUIRED BY THE SENSES.

Attitude.—The educated eye will often detect the character of a disease in the posture assumed by a patient. A lad in the early stage of hip-joint disease advances the limb, flexes the knee, and everts the foot of the affected side. In luxation of the femur, the variety of displacement is determined in a great degree by the position in which the extremity is found. A luxation of the scapulo-humeral articulation will be predicated on the posture of the elbow. In acute peritonitis, the dorsal decubitus and the drawn-up limbs sufficiently declare the internal inflammation. A limb so rotated after an accident that the outer side of the foot rests upon the bed, will suggest at once the probability of a fracture through the neck of the femur. A child who walks with a stiff, studied air, having the shoulders drawn up, and with abducted arms, furnishes the signs of spinal caries. In hydrothorax and in extreme ascites, where the breathing is difficult, the upright position in bed is the one generally observed; and in order to fix the points for the insertion of the pectoral, the great serrati, the sterno-mastoid, and other muscles of extraordinary respiration, the hands are planted upon the bed and the head is thrown back, so as to acquire additional dilating power over the walls of the chest. In cases where the patient constantly slips down towards the foot of the bed, we have the evidence of extreme debility. The above are only a few examples of a great number which might be adduced under the head of position: indeed, there is scarcely a disease or an injury which is not in some way accompanied by something peculiar in the disposition of the head, trunk, or extremities.

Surface expression.—The knowledge gained from the expression of the face and other parts of the body is highly instructive. Disease, both mental and physical, displays its signals upon the countenance in characters so legible that they admit of an easy interpretation. The white, puffy, or sallow face attending certain degenerations of the kidneys, the clay- or straw-color complexion in cancer, the waxy hue and extreme pallor of the face and lips after excessive loss of blood, the red stripe across the nose and the unilateral flush of the cheek in pneumonia and in phthisis, the timid look and downcast eyes which so commonly betray the practice of secret vices, the strongly-contracted corrugated muscles of the eyebrows in acute abdominal inflammations, the spasmodic closure of the eyelids against the light in strumous ophthalmia, and the strabismus following cerebral trouble or defective accommodation, are examples in point. To these might be added the rapidly expanding and contracting alæ of the nose in embarrassed respiration, the dilatation or contraction of the pupils in injuries of the brain, the sardonic grin of tetanus, the form of the teeth in transmitted syphilis, the drooping eyelid in certain intra-cranial accidents, and the sharp, wasted, and contracted features of the Hippocratic face, betokening impending dissolution; with many others equally illustrative.

Turning to other parts of the body, we may mention the flattened shoulder and the salient acromial process of the scapula following dislocation of the humerus, the prominence of the spinous processes of certain vertebræ and

the resulting curvatures seen in Pott's disease, the loss of the sharp definition between the buttocks and the thigh in coxalgia, the enlargement of the epiphyseal cartilages in rickets, the depressed and adherent cicatrices following necrosis, the scars in the groin and elsewhere which tell a tale of previous syphilitic trouble, and the elongated prepuce often accompanying vesical calculus in children.

Mensuration.—The careful measurement of parts and their comparison with corresponding portions of the body constitute another means of diagnostic information. The metallic ribbon or the tape-line, with its graduated numbers, is usually employed for this purpose. In fractures and dislocations of the thigh this method is often resorted to in order to ascertain the length of the injured as compared with the sound limb. When a comparison between the lower extremities is to be made in cases of fracture, it is absolutely necessary, for the accuracy of the measurement, that the patient be laid upon a firm, unyielding surface, that the limbs be placed side by side, and that the trunk be in a straight line with the extremities: the least lateral inclination of the body or the pelvis will necessarily alter all the details of the mensuration. These measurements, when feasible, should always be made between certain salient portions of the skeleton which from their fixed and unvarying position can usually be relied on: thus, the anterior superior spinous process of the ilium, the tuberosity of the pubic bone, and the internal malleolus of the tibia are the landmarks for measurement in fractures of the thigh; the anterior superior spinous process of the ilium, the tuber ischii, and the trochanter major, in dislocations of the femur; the internal and external condyles of the humerus, with the olecranon process of the ulna, in fractures or luxations of the elbow-joint, etc.

The tape-line is often employed in determining the difference between the sides of the thorax in serous effusions into the pleural sac, and also in ascertaining the circumference of an enlarged joint as compared with its fellow, in which case the two limbs should be placed as nearly as possible in the same position, either of flexion or of extension.

Deviations of the spine from the perpendicular are sometimes tested by the plumb-line, and antero-posterior curvatures are measured by a ribbon of malleable metal. One of the most accurate modes of outlining these curvatures is to take a plaster roller a few feet in length, and, wetting it in water, run it up and down the vertebral column longitudinally. In a few minutes the plaster will set, when the strip may be removed, and will prove to be an exact cast of the curves.

Form.—The form of a swelling may be determined, in many instances, by a simple glance of the eye; in other cases it can only be learned by the sense of touch. For example, a patient may present a large tumor in the neck or on the back. With the eye it is seen to have a uniformly round, oval, or pyriform surface, but when the same swelling is felt with the fingers it is found to be lobulated, the presence of which peculiarity may aid materially in deciding the diagnosis. Alteration in the figure of parts conveys, in fractures and dislocations, very important information. An angular projection in the continuity of the thigh, of the arm, or of the leg, following an injury, is strong presumptive evidence of fracture.

The shape of a swelling is frequently determined by anatomical peculiarities of structures, and when these are known the practitioner is often enabled to fix both the location and the nature of the enlargement. Thus, a swelling sharply bounded by the base of the jaw above, by the horn of the hyoid bone below, by the angle of the jaw posteriorly, and by the anterior belly of the digastric muscle anteriorly, is known to occupy the chamber allotted to the sub-maxillary gland. A swelling which appears upon the front of the thigh below Poupart's ligament and to the outer side of the crural vessels, may have followed the sheath of the psoas and iliacus internus muscles, and this circumstance would suggest at once a psoas abscess and the existence of caries of some of the vertebræ belonging to the lumbar region of

the spine. A swelling in front of and circumscribed by the borders of the patella tells its own tale,—it is dropsy of the bursa. So also is it with those enlargements seen in connection with the tendons about the wrist.

Color.—The knowledge communicated by observing the color of the surface of the body is very important. There is the bright scarlet red which accompanies acute inflammation; there is a dark dusky red, which belongs to low forms of erysipelas; and there is a dull red color, blended with purple, or mottled, which is characteristic of chronic inflammation and of venous obstruction. Dark purple, yellow, and green discolorations appear beneath the surface, commonly called *ecchymoses*, which are the result of broken vessels, chiefly venous: when such extravasations find their way to the surface several days after a severe injury to the limb, they should suggest the propriety of instituting the most careful examination, for fear a fracture has been overlooked. There is also an azure blue and purple color, which precedes the ulceration of malignant growths, and a mottled or black hue, which betokens the dissolution of the soft parts.

Translucency.—The nature of many swellings is determined by the transparency of their contents. This test can be applied in two ways,—first, by taking the patient into a darkened chamber and holding the tumor, previously made tense, between a lighted taper or candle and the observer, the latter at the same time resting the hand vertically over the upper surface of the swelling, in order to intercept the upper rays of light; secondly, translucency may be ascertained in a strong sunlight by folding a sheet of paper into a hollow cylinder, and, with one extremity resting upon the part, viewing the swelling through this tube. By either of these devices we are able to diagnose hydrocele, meningocele, spina bifida, and other cysts.

Muscular movements.—Movements may be either less or greater than those which are natural, and in each case they supply valuable aid in diagnosis. When the ribs are broken or a lung is collapsed, the walls of the chest, on the affected side, remain almost entirely quiescent. An injury to the cervical vertebræ will render the head stiff and motionless; an inflamed joint is intolerant of the least disturbance; and when an arm or a leg is broken, all voluntary movements are as a rule at once suspended.

Exaggerated movements are frequently witnessed as a result of morbid conditions: hence the rapid action of the chest-walls in cardiac and pulmonary disease. There are exaggerated movements which arise from a defect in co-ordination; for example, the oscillating eyeball in nystagmus, the tremor of paralysis agitans, the muscular disturbance in chorea, etc. There are mal-directed movements, such as belong to locomotor ataxia, and others again which are automatic and indicative of extreme danger, as picking the bedclothes, or grasping at imaginary objects in the air,—conditions so often seen in low forms of fever.

Movement, again, may be executed of an awkward, eccentric character, as where a person, in walking, instead of advancing the limb directly forward, swings it around in the segment of a circle. Here the quadriceps extensor of the thigh is paralyzed, and the work of the latter has to be substituted by the action of another group of muscles.

Sounds.—The sense of hearing, especially in a medical point of view, is one of the most valuable channels for the reception of diagnostic knowledge. It is through the ear that the most occult changes which take place in the chest are detected. Auscultation, however, is not without its value to the surgeon. It is in this way that he is able to recognize those serous and purulent accumulations in the pleural sac, or in the pericardium, which frequently demand surgical interference for their removal.

To hear the clink of the steel sound is much more decisive of the presence of a urinary calculus than any knowledge obtained simply by the sense of touch. The peculiar bruit which forms one of the most constant signs of aneurism can only be recognized through the organs of hearing; and it is also true of

that sound which has been compared to the noise made by a fly or a bee in a paper bag, and which is present in arterio-venous aneurism.

It may be necessary to resort to the use of this sense in order to detect the crepitation of fracture. By the use of the stethoscope the ear is greatly assisted in the detection of both normal and abnormal sounds.

TOUCH.

By the sense of touch a knowledge of the consistence, movement, weight, exact form, sensibility, and temperature of a part is obtained. The touch should be cultivated with the greatest care. Many errors have been committed, and some lamentable blunders, from defective tact.

Consistence.—The more liquid the contents of a swelling the softer will be its consistency. Inflammatory transudations into the soft parts, when they consist of serum, are usually very compressible, can be displaced, and pit on pressure. When they consist of fibrogenous and cell materials, they are firm and hard, commonly called *indurations*, or infiltrates. The dense hard wall of lymph at the circumference of an abscess is an example in point.

When the contents of a growth are liquid and inclosed by a limiting wall, or by a sac, the sensation imparted to the fingers on palpation is one of fluctuation. Highly vascular and fatty growths, like encephaloid and adipose tumors, may, on the application of the same test, yield a similar sensation, though, when carefully studied, it will be found to be elasticity rather than fluctuation. When air is extravasated through connective tissue, it is revealed by crackling or crepitation on pressure.

Movement.—The attachments and the depth of tumors are ascertained by the degree of motion which they allow; and their nature is often revealed, as in aneurism, by their centrifugal expansion. Undue movement in the continuity of a bone, accompanied by crepitation, is indicative of fracture; while diminished motion or rigidity is a symptom of luxation, or of anchylosis.

There is a motion which travels in short waves, and which causes a tremor or *fremitus*. It is one of the tests employed by the practitioner in making explorations of the chest for effusions in the pleural sac,—the hand being placed upon the thorax while the patient speaks.

Weight.—Considerable importance is attached to the weight of a tumor in forming a differential diagnosis. A growth in the mammary gland or in the testis, which, when raised by the fingers, gives the impression of weight out of proportion to the size of the body, furnishes reasonable grounds for regarding the disease as either scirrhous or fibrous in its nature.

Exact form.—It is only by handling a swelling or tumor that an exact idea of its form can be attained. In this way a group of enlarged inguinal glands, by the lenticular disposition of its parts, can be distinguished from a hernia; a fatty growth can be recognized by its lobulated form. In the same way may the surgeon trace the outline of the fœtus in cases of extra-uterine pregnancy, recognize the knobbed surface of a uterine fibroid, and detect the notched border of an enlarged spleen.

Temperature.—Though the touch is a rough means of ascertaining temperature in comparison with instrumental measures, yet to lay the hand upon a part is quite sufficient in many instances to guide our therapeutics when great delicacy of observation is not required.

SMELL.

By the sense of smell the surgeon may discover, in the peculiar odor from the nasal passages of a patient suffering from catarrhal disease, the existence of necrosed bone, before any exploration of the fossæ is made; pyæmia is sometimes revealed in the sweet or fresh-hay odor which emanates from the breath; a stercoraceous fistula is known by the existence of a fæcal smell in the discharges which escape; and in a perineal sinus its connection

with the bladder may be predicated on the urinous odor which accompanies the issuing fluids. The peculiar earthy smell of the soft parts in a state of mortification is another familiar example in point.

EXAMINATION OF THE INTERNAL ORGANS.

It will often be necessary, in order to render a diagnosis exhaustive, to extend the inquiry to the state of the different organs of the body.

Circulation.—The state of the heart and blood-vessels, as regards both their action and their structural alterations, demands a careful consideration. Valvular defects are recognized by characteristic sounds, which it is the province of the medical rather than of the surgical diagnostician to describe. In the administration of anæsthetics and in estimating the capacity of patients to undergo prolonged operations, such alterations of structure must not be overlooked. The relation between atheroma, aneurism, and senile gangrene; the varicose condition of the superficial abdominal and thoracic trunks, as indicative of deep-seated obstruction to the venous circulation; embolic plugging of the veins in connection with phlebitis; the venous murmurs in the great vessels of the neck in anæmic conditions of the system; and the connection between lividity of the face and pulmonary or cardiac disease,—these are a few of the subjects which will require investigation.

The pulse, as an index to the state of the circulation, requires for its proper interpretation considerable experience. Its frequency, force, volume, and rhythm, or regularity, are the chief features to be noted.

The pulse, it must be remembered, varies in all these particulars at different times in the same individual, even in a state of health. There is no absolute standard for the arterial beat; what in point of frequency may be normal in one individual may be abnormal in another: consequently it is a wise precaution, when estimating the condition of the circulation in a patient, to inquire if any peculiarities in this respect are known to exist. In females or in children the action of the heart and arteries is generally quicker than in males or in adults.

The presence of the physician, or the exhibition of any display by the assumption of a grave or wise air on his part, or even by the formal exposure of a watch, will often disturb the circulation so as to vitiate the examination and render all inferences drawn from it unreliable. Hence the medical man, with the address of one learned in his art, will prepare the way for his investigation by some preliminary inquiries of a general character, until the perturbation attending his visit has passed over and the patient feels entirely at ease in his presence.

The pulsations are variously affected by different morbid conditions,—reflex, functional, and organic.

In infra-diaphragmatic inflammations the pulse is usually contracted, hard, and cord-like; in inflammations above the diaphragm it is full, round, and bounding. The effect of compression and of concussion of the brain on the circulation is very marked. In the first the beat of the artery is full and slow; in the second it is slow and thready. A severe hemorrhage imparts a peculiar character to the pulse; the artery is small, and the blood flows through it in such a manner as to communicate to the fingers a feeble but sharp, tremulous, and jerking sensation. The beat of the vessel is often changed in its rhythm; it may be intermittent, irregular, or dicrotic, either as a result of gastric derangement or from organic disease of the heart. A very rapid pulse, or one habitually frequent, betokens danger, and in compression and concussion, when the pulsation of the heart from having been slow becomes rapid, a fatal termination is probably near at hand.

Thermometry.—An increased evolution of heat is a constant attendant of fever, and the degree of caloric will be in correspondence with the extent and rapidity of tissue-change. The temperature of persons in health varies very little, oscillating between 98.6° and 99.5° Fahr. The first observation

to determine local temperature in inflammation was made by John Hunter, though several thermometric observations in disease were practiced as early as 1638, by Sanctorius. There are two forms of the clinical thermometer in common use. (Figs. A, B.) The instrument when used should be placed in the axilla or under the tongue. When in the former region, the part should be wiped dry and the arm closed against the side for a short time, after which the thermometer may be introduced. The time usually required for the mercury to reach the proper numeral is from ten to fifteen minutes. Two observations a day are usually sufficient, and these should be made about eight o'clock in the morning and about seven in the evening, the registration being kept on forms specially provided for the purpose. Generally there is a uniform correspondence between the rise of temperature and the frequency of the pulse,—that is, with any degree above 98° Fahr. there is an increase of eight or ten beats of the heart. All elevations of temperature above the normal standard are expressions of tissue-waste, and when reaching 105° and upwards the danger to a patient is very great.

Fig. A. Fig. B.

Clinical thermometers.

Respiration.—Observations drawn from the state of the respiration should include the frequency, the ease, and the regularity of the process; whether the inspiration or the expiration is most impeded, and the effect of all such disturbances on the walls of the chest or of the abdomen, and on the voice.

The frequency of the respiration is increased by any cause which interferes with the expansion of the lung-tissue or which disturbs the pulmonary circulation. Thus, in pneumonia, where the pulmonary tissue is filled by inflammatory infiltration, and in hydrothorax or in emphysema, in which the fluid crowds the lung back towards the spine, preventing the free entrance of air into the air-cells, nature instinctively attempts to compensate for the diminished aeration of the blood by numerous short respiratory acts. The breathing is modified by cardiac disease. When the patient is reposing quietly in the recumbent position it may be entirely natural; if obliged to turn over in bed or to rise it becomes quickened; and on walking or climbing an ascent it becomes greatly hurried and labored. Emotional causes also operate to disturb the regularity of the respiration. Joy, apprehension, or highly-wrought anticipation frequently so unsettles the quiet currents of feeling that, like a lake stirred by fitful gusts of wind, the breath goes and comes, sometimes with regularly-measured intervals, and at other times in tumultuous and rapid movements of the chest.

In cases where the depurating function of an important eliminating organ like the kidneys is from structural disease imperfectly executed, the brain and other organs soon begin to feel the toxic effects of the products of retained tissue-waste. In atheromatous conditions of the vessels of the heart the circulation moves tardily, and it is not uncommon under such circumstances to witness a singular irregularity in the breathing,—at one time so quiet, while the medulla is dosed with anæsthetic blood, as scarcely to be observed, and at another time, when the necessities of the organs compel them to cry out for fresh blood, carried on with the greatest rapidity until the want is supplied.

Inspiration is in some instances more impeded than expiration. The cause of this is to be sought for in a mechanical obstruction of the trachea, the larynx, or the glottis. Thus, in œdema of the glottis, in croup, or where the passage of a bolus of food is arrested at the termination of the pharynx,

the canal of the vocal respiratory tube may be so encroached upon as to resist the entrance of air. In pleurisy or in pleurodynia the inspiratory act will be brought to a sudden arrest before its completion, and in fracture of the ribs both inspiration and expiration are conducted, so far as the injured side is concerned, with the utmost quietude, and may be in rare instances entirely suspended.

One of the marvelous adaptations to extraordinary conditions which exist in the human body is the interchangeableness of function between its different parts. This is beautifully illustrated in the mechanism of the chest and of the abdomen. When the ribs are broken, the fractured walls of the thorax become almost motionless, the respiration being carried on by the diaphragm and the abdominal muscles; while in a case of peritonitis the reverse is true,—the abdominal parietes are rendered quiet, being supplemented by the muscles of the chest. In cases of intra-cranial pressure the respiration is conducted in a slow, labored, and noisy manner.

There are frequently unusual sounds accompanying the respiration which have their significance. The stridulous crowing and wheezing noise often accompanying difficult inspiration is due to the air rushing through a narrow aperture in the larynx or in the trachea. There is a grunting expiration which is associated with disease of the spine in children: the râles which presage approaching dissolution are due to the passage of air through the laryngeal and tracheal mucus: the stertor attending the breathing in cerebral compressions is faucial, from paralysis of the soft palate.

There are alterations in the voice which are produced by a modification of the air passing through the vocal apparatus, and which indicate changes of structure in the fauces, pharynx, and larynx, and in the system at large. From these causes arise the inarticulate mumbling of words in tonsillitis and post-pharyngeal abscess, the whisper in paralysis or in swellings and tumors about the vocal cords, the indistinct, guttural, and broken words which attend the dyspnœa of aggravated lung and heart disease, and the feeble, tremulous voice of extreme weakness from the exhaustion of febrile and other diseases. Hiccough and sighing are also phenomena which become sources of anxiety, from their frequent connection with great debility or the sudden invasion of mortification.

The surgeon sometimes solicits the assistance of the respiratory function to aid him in the diagnosis of disease, as coughing in suspected cases of hernia.

Nervous system.—It is often a very difficult part of the surgeon's duty to determine the exact value of many nervous phenomena which crop out in the progress of a case. The inquiry under this head will include intelligence, sensation, and motility.

Intelligence.—The whole mental and moral condition of a patient may be changed by physical disease or injury. This change may consist, first, in an intellectual aberration or delirium, a condition very common in affections attended by great arterial excitement. This delirium may be passive, muttering, or incoherent, characteristics which belong to asthenic states of the system; or it may be wild and uncontrollable, as in some forms of cerebritis. Again, the delirium may be intermittent, subsiding with the febrile paroxysm, and re-appearing with its recurrence, a condition not to be regarded as particularly dangerous; or it may be constant, as in meningeal and cerebral inflammations, and suggestive of a much more serious state of things.

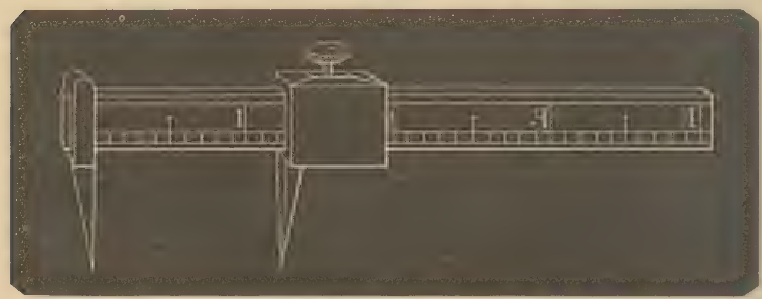
Sometimes the intelligence is only dull, heavy, obtuse, not absolutely deranged; the patient can be roused, and will respond correctly to questions which may be asked, but soon lapses into a lethargic state. Examples of this nature are common in œdema of the brain, in slight forms of uræmia, and in concussion of the brain. Complete suspension of the intelligence is a constant attendant of cerebral compression. Mental dullness, passing into stupor, and finally into profound coma, indicates such serious lesion of the

brain that a fatal termination may be predicated with considerable certainty. There is a form of quiet delirium, often delusive in its drift, which follows the extraction of cataract in aged persons, appearing to be in some way dependent on impressions communicated from the eye to the brain, and which often proves very troublesome. The patient is constantly trying to remove the dressings, can with difficulty be restrained from getting out of bed, and often imagines himself away from home. In all cases of delirium the surgeon must carefully push his inquiries in every direction to ascertain whether this mental disturbance is the result of reflected irritation or of disease in the brain-tissue, the latter of course investing the case with the gravest aspect.

The moral endowments are likewise liable to many and singular perversions, the result of physical disease. Among these may be mentioned the irritability, obscenity, and profanity which characterize some cases of concussion of the brain, the cerebral disturbance from febrile excitement, and the nymphomania which is sometimes developed by both local and central irritations.

Sensation.—Cutaneous, mucous, and muscular sensibility also demand consideration. The instruments used for determining the cutaneous sensibility are the æsthesiometer (Fig. C), an ordinary pin, the compasses,

FIG C.



Æsthesiometer.

and a feather, applied when the eyes of the patient are closed. For testing the muscular sensibility and contractility, the electro-galvanic battery is used.

The sensibility of the skin may be greatly diminished under the anæsthetic action of certain morbid poisons circulating in the blood, as that of syphilis, or in consequence of nerve lesions, giving rise to numbness. It may be excessively exaggerated, so that the gentlest touch with the finger, or even with the plume of a feather, will provoke the most extraordinary manifestations of suffering, a condition often witnessed in hysterical joints and in imaginary disease of the spine. This perversion of sensibility is exhibited in a diversity of ways. It may consist of intense itching, as after poisoned wounds; of a horrible feeling of ants crawling over the surface; of a localized burning sensation; of a sense of being brushed with nettles, or of a cold stream of air passing rapidly along the surface of a part. These states of the peripheral nerves may be caused either by reflex irritants or by disease of the ganglionic masses of neurine, or of the nervous cords themselves.

Parts normally of low sensibility become acutely sensitive when inflamed: the violent paroxysms which involve the entire muscular system of a child with an inflamed gum, or the exquisite suffering from a similar state of the integument of the heel caused by pressure, demonstrate the truthfulness of this statement.

Pain is intensified sensibility, communicated to the consciousness probably through special tracts of the medulla spinalis. Much may be learned from the

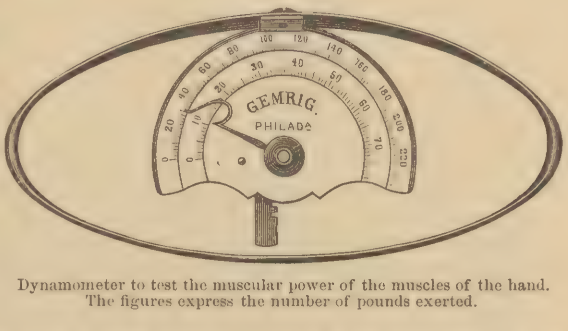
character or quality, the location, and the duration of suffering. Shooting and darting pains are peculiar to scirrhus; burning pains, to inflammation of the skin; throbbing sensations, to the presence of inflammatory products under resisting structures, as in whitlow; sickening pain, to contusions of the testicles; and gnawing and boring feelings, to caries and necrosis.

When located at the end of the urethra, pain points to vesical calculus; shooting down from the loins to the testicle, as in renal colic, it indicates the presence of a stone in the urethra; at the point of the right shoulder-blade, it is frequently a result of hepatitis; and at the knee it is among the most common signs of coxalgia. These are examples of pain remote from the actual seat of disease; and the surgeon should always endeavor to learn the true source of this symptom. The patient should be invariably asked to locate the sensation. Constant suffering arises either from inflammatory pressure or from the pressure of morbid growths; intermittent pain is, for the most part, non-inflammatory or neuralgic. Of this nature are the supraorbital and facial attacks of suffering and the pain of colic. The differential diagnosis of pain from the two causes is further established by the intolerance of the affected part to pressure in the former, and the relief imparted by the same pressure in the latter. In inflammatory pain the severity of the suffering is generally less than in that of neuralgia. A fixed and persistent pain, in a definite locality, is a symptom which should never be lightly passed over by a physician. Fugitive pains have commonly, though not always, a rheumatic origin. In estimating the value of this symptom in arriving at a diagnosis, the temperament of the patient must be considered. All persons are not alike affected. Some endure tortures in a stolid, stubborn, and uncomplaining manner, while others on the slightest attack will exhibit the most extravagant demonstrations of suffering.

Motility.—Muscular movements possess the highest importance in solving some of the morbid problems which come within the domain of surgical diagnosis. Eccentric movements of muscles may depend primarily on the condition of the central masses of neurine from which they are energized, on the state of the nerves running in their substance, or on alteration of the sarcous cells. The phenomena resulting from these sources are loss of power, tremor, twitchings, spasms, contraction, choreic movements, atrophy, etc.

Loss of power may affect a single muscle or a group of muscles, one extremity or the entire body. When it includes one side of the body, the cause will naturally be referred to the brain; when an arm, or a leg, or both lower extremities, are affected, the origin will usually be spinal. The pressure of a tumor, the extremity of a displaced bone, or a mass of redundant callus may completely paralyze one or several muscles. A sudden and sustained exercise of muscular power, particularly if it is exerted under an unfavorable disposition of leverage, by drawing on the nerve-force too heavily, occasionally leads to a temporary paralysis (*reflex*) of the overtaxed muscles. The power of the muscular contraction is measured by an instrument called a dynamometer. Fig. D is an illustration of one variety Paralysis of certain groups of muscles follows fracture of the vertebræ, and explains many deformities, as club-foot, spinal distortions, etc. Tremors are, unfortunately, too often the effect of irremediable central diseases. Spasms and twitchings may arise from some local irritant, as a spiculum of bone, a pre-

FIG. D.



Dynamometer to test the muscular power of the muscles of the hand. The figures express the number of pounds exerted.

ternaturally narrow prepuce, dentition, or from causes located in the stomach or in the uterus, and therefore amenable to treatment. Permanent contractions of the muscles are usually unpromising affections, being frequently associated with sclerosis of the anterior column of the medulla spinalis. Loss of power may again be due to muscular atrophy or to fatty degeneration, the sarcous cells being replaced by fat, the energizing factors being unimpaired. In all these pathological phases of the motor apparatus the use of faradaic and electrical stimuli becomes necessary, not only to determine physiological activity, but also to detect in what particular the imperfection consists,—that is, whether it is the muscle, the source of its power, or the medium through which the power is communicated, that is at fault.

The gait, posture, and various attitudes of the body should also in this connection attract particular attention. The walk of a child, or the attitude assumed when standing, reveals tubercular disease of the spine or of the hip. The habitually flexed state of the thigh gives rise to a suspicion of psoas abscess. The advanced lower extremity, with the foot everted or inverted, and the forward inclination of the body, following an accident, suggest the probability of a femoral luxation.

DIGESTIVE APPARATUS.

The influence which the digestive organs, from their extensive sympathies, exercise in the production of morbid phenomena is almost incalculable. Extensive disturbances of the respiratory, circulatory, and nervous systems are frequently referable to organic or functional disorder of some portion of the digestive apparatus. It should be examined in detail. The tumid, the pale, and the scabbed or fissured lip respectively indicate a strumous and anæmic state of the system and general disorder of the intestinal and glandular secretions. Gums spongy, shrunken from the teeth, and bleeding when touched, imply faulty or scorbutic conditions of the blood, or the injudicious use of mercurials.

Lead, silver, and pulmonary tuberculosis often register themselves by a characteristic line upon the gums, and from the surface of the latter may project morbid growths of different kinds. The teeth of the child may, by their notched edges, tell a tale of parental vice, to which allusion has already been made.

The state of the tongue is a valuable index to general and local disorder of the system. When dry, there is an arrest of secretion,—a common condition in febrile excitement, and in itself not very important; but if to this there be added a rigid prominent state of the papillæ and a dark color occurring during the progress of traumatic or other fever, the case is beset with danger. In faucial and gastro-intestinal inflammation, and in the exanthemata, the organ is red and occasionally glazed; in anæmia it is pale, soft, and flabby.

The coating upon the tongue may be scanty and white, an indication usually for the use of tonics; it may be thick and have a white and yellow color intermixed, as in disordered liver-function; and it may be incrusted with a dark and pasty substance, consisting of vitiated secretions and disorganized blood-corpuscles; this coating may not only adhere to the tongue, but also often gathers about the teeth and gums (*sordes*), and may be regarded as denoting danger.

A white and yellow coat may accumulate on the tongue from congested or inflamed fauces or pharynx.

The form of the tongue should be noted. In habitual disturbance of the digestion, and in feeble states of the general system, it will often be found broad, soft, and fissured, and with rounded edges. In inflammatory diseases of the respiratory tube it is sometimes depressed in the centre, giving the sides an elevated appearance; and in meningitis and cerebritis, as long as the brain is not subjected to too great pressure, it will be long, narrow, and pointed.

The tongue may be altered in form and present a blue, spongy appearance from angeiomatous growths.

The motions of the organ should not pass unobserved. A tremulous tongue, or one which is protruded slowly and with difficulty from the mouth, implies great debility and betokens danger. When it is thrust out to one side, there is probably unilateral paralysis, or, at least, paresis of its muscles on the opposite side.

An inspection should likewise be made of that region which lies between the tongue and the floor of the mouth, into which project the sublingual and submaxillary glands, and where ranula and salivary calculi are readily detected when present.

Both the tongue and the inside of the cheeks should be examined for ulcers and mucous patches when there is reason to suspect a syphilitic taint.

Embarrassed deglutition or enunciation, hoarseness, and stiffness of the neck will suggest a careful inspection of the fauces and pharynx, noting if there be hypertrophy of the tonsils, elongation of the uvula, relaxation of the velum palati, enlargement of the pharyngeal glands, or any post-pharyngeal prominence which might be invoked to explain the symptoms complained of.

When signs of obstruction in the œsophagus are present, the examination should be made by carrying appropriate bougies or probangs along this part of the alimentary tube.

Vomiting or retching, especially when preceded by a dyspeptic history, demands a careful exploration of the abdominal contents and of the hernial passages, for tumors, obstructions, and rupture. The appearance and odor of the matters ejected from the stomach also require notice.

The outlines of enlarged organs, like the liver and the spleen, or of a displaced organ, such as the kidney, may, with care, by percussion and manipulation, be accurately traced. In distention of the abdominal parietes from accumulations of fluid, the diagnosis will be facilitated by palpation, by observing the flattened or prominent flanks, and by the use of the exploring needle.

The escape of blood from the rectum after a difficult defecation may be traced to its proper cause by ocular, digital, and instrumental exploration, and as this symptom may attend hemorrhoids, fissure, stricture, ulcers, cancer, and intussusception, it may be necessary to resort to all of the above-mentioned measures. The form of the fæces will often reveal rectal stricture, being in small cylinders, like pipe-stems or pencils, sometimes round, and at other times flat, angular, or broken into fragments. Putty-colored dejections imply the absence of bile in the intestine; and when of the color and consistence of tar they often consist of venous blood. Pain at the anus in some instances is itself diagnostic of the disease. When coming on a short time *after* defecation, and increasing in intensity for several hours in succession, it belongs to anal fissure.

Tenesmus is not only a sign of colitis, but may be also excited by a foreign body in the rectum, and when accompanied by frequent and slight watery passages, it is an evidence of fæcal impaction.

GENITO-URINARY APPARATUS.

The sexual system of both males and females is so conspicuously concerned as a disturbing factor in many of the derangements of the body that it cannot be ignored in the analysis of many cases of disease and injury, nor should it, in such inquiries, be dissociated from the urinary organs. The loss of the venereal appetite, its inordinate excitement, or its presence without the ability to execute the act, are conditions which require a careful examination of the cerebro-spinal centres, the organs themselves, and the state of the urine, as well as an investigation of the habits of the patient.

The existence of spermatorrhœa, or of secret indulgences,—a vice common to both sexes,—must not be overlooked in instances where a patient, in con-

sequence of the presence of palpitation, nervous restlessness, dyspepsia, and loss of strength, applies for relief without having any detectable organic lesion to explain these symptoms.

Priapism and its connection with spinal, cerebral, and cerebellar injuries; the retraction of the testicle in renal colic, with pains along the course of the ureter; phimosis; elongation of the prepuce; urethral pain and its location, whether at the extremity of the glans penis, at the neck of the bladder, or along the entire length of the canal, and whether experienced at the commencement or at the termination of micturition, also the size and shape of the stream of urine, are all subjects for inquiry in connection with stone, prostatic hypertrophy, or stricture. Of like importance is the existence of urethral discharges, of stricture, and of an irritable or inflamed bladder.

In females the menstrual function, as regards its establishment, excess, suppression, irregularity, or decline, must be considered as the probable cause of constitutional disturbance.

So also in irritable bladder the surgeon must explore the viscus for stone, and the urethra, the vagina, and the rectum for morbid growths. In urinary incontinence, the vesico-vaginal septum should be examined for a possible fistula; and in the same defect in children, the rectum should be searched for ascarides. Nor would such examination be complete unless the vagina and the uterus were included in the exploration, as only by such precautions could the existence of polypi, or of fibroid or other growths, be detected. The existence of any pale red, watery, or chocolate discharge, with an unpleasant odor, from the vagina should also be noticed.

The importance of sound kidneys to the success of a surgical operation is so commonly recognized that no surgeon, understanding his duty to a patient, would undertake any such procedure, save in case of emergency, without first ascertaining their condition. The examination of the secretion should be physical, chemical, and microscopic, and should include quantity, specific gravity, color, reaction, and composition.

Albumen, pus, muco-pus, blood, urates, phosphates, and oxalates must each be carefully noted and traced to their proper source. These subjects will be treated of in detail under the head of diseases of the genito-urinary organs.

Except in two or three instances, nothing has been said with regard to the instruments commonly used for diagnostic purposes, as these will require to be noticed in connection with special subjects.

PRINCIPLES AND PRACTICE

OF

SURGERY.

CHAPTER I.

INFLAMMATION.

In the study of any science or art there are certain elementary facts which it is necessary to master before the inquirer is able to comprehend and use the truths of the first, or successfully wield the resources of the last. Surgery is both a science and an art, and he who aspires to the possession of its principles and their successful application will be confronted at once with a process so universal in its operation, so constantly recurring, that to ignore its diligent study is to enter upon one of the most responsible of the learned professions with the certainty of disaster and defeat. This process is *inflammation*. The word is a very old one, and its derivatives are found in almost every language, invariably expressing the idea of heat.

If the surface of the body be pricked or scratched with a needle, if a tendon be divided, a tumor removed, a bone broken, a limb amputated, or an artery tied, inflammation will be present: it is a double-edged sword, cutting either way, for good or for evil; the friend of the surgeon, or his deadliest enemy.

During the year 1874, in the city of Philadelphia* there was a total mortality, exclusive of still-born children, of fifteen thousand four hundred and twenty-four, of which number not less than eleven thousand may be fairly attributed directly or indirectly to inflammatory complications. A disease so generally present must have a transcendent interest for both physician and surgeon. Until the time of John Hunter, comparatively little progress had been made in the systematic study of the disease. For thirty years, this most remarkable man of his time, pursuing a purely inductive method, devoted himself to its study; and he succeeded in giving to the world the first methodical arrangement of the subject, in the form of a treatise which exhibits a degree of patient industry, research, and logical acumen that has secured for his name and memory an enduring immortality. Inflammation is a concrete term, designed to express the totality of several distinct processes, and therefore incapable of being defined by any single word. It is sufficient for our purpose here to say that it is a form of *hypernutrition*.

Varieties of Inflammation.—The well-marked differential characteristics of inflammation have given rise to various classifications founded on certain dominating features, which may be arranged after the following order:

1. *The tendency of the disease.*—When inflammation passes through its stages

* Report of the Board of Health for the City and Port of Philadelphia for 1874.

in an orderly manner and then subsides, leaving the tissues unharmed, it is termed *healthy;* when marked by great violence, and accompanied by much structural change, it is *unhealthy*. These terms possess some fitness, and might without any great impropriety be accepted as sufficiently generic to comprehend the various forms of inflammation. It may be urged that to speak of a morbid action being healthy is a contradiction in terms; but I can discover no inaccuracy in the use of the word. It will be conceded that there is a force ever present in all pathological mutations of structure, which resists destruction and tends to conserve and restore. The old physicians called it the *vis medicatrix naturæ*. There can certainly be no impropriety in regarding this as a healthy influence. It would include all those inflammations in which the restorative principle or power is dominant, while the unhealthy class would include all those in which the same force has been overmastered and the tissues have been altered or destroyed to an unusual extent.

2. *Constitutional vigor.*—When inflammation occurs in a good constitution, and advances rapidly to its termination, it has been called *sthenic;* when in a feeble and broken-down constitution, progressing tardily, *asthenic*.

3. *Peculiarities of the blood.*—This feature forms the basis for the so-called *specific* inflammations. Thus, we have the rheumatic, gouty, syphilitic, erysipelatous, scorbutic, and scrofulous varieties.

4. *Textural peculiarities.*—This was purely an anatomical division. Every tissue, when inflamed, was supposed to present phenomena peculiar to itself, and unlike those of any other. According to this view, there were as many kinds of inflammation as there were tissues in the body. It is quite true that inflammation of cellular tissue tends to suppuration, and that of serous membranes to a transudation of serum or lymph; but none of these characteristics can properly be regarded as constituting philosophical grounds for generalization, since they deal with something other than the essence or nature of the process involved.

There is also *common* inflammation, such as may arise from ordinary causes, as blows, irritants, etc.; *latent* inflammation, in which the symptoms are so faintly expressed as to escape observation; *diffuse* or *circumscribed* inflammation, according to its tendency to spread or remain within definite bounds; and many other varieties, which unnecessarily embarrass and encumber the subject.

The division which I prefer to adopt is one that is exceedingly comprehensive, and has, moreover, a strong hold upon the professional mind,—namely, that into *acute* and *chronic*. *Acute inflammation* embraces all cases or varieties which run their course quickly, the symptoms being well marked: it is generally met with in good constitutions. *Chronic inflammation* includes all cases in which the process is slow, the usual signs, such as redness, swelling, heat, and pain, being present in a moderate degree, and in which there is a tendency to linger for a long time in a part, manifested by the presence of some tenderness, a brownish-red or purple discoloration, a certain amount of thickening or induration of tissue, and which often disappears and returns on the slightest provocation. Such a form of inflammation may exist from the beginning, or it may be the result of a gradual degeneration of the acute, either from constitutional influences or inefficient treatment.

Causes of Inflammation.—In general, inflammations arise from causes which are either *external* or *internal*, and are divided into *predisposing* and *exciting*.

By a predisposing cause is meant any influence or influences which render a part, or organ, peculiarly prone to inflammation upon the application of an excitant which, under other circumstances, would prove altogether insufficient.

By an exciting or determining cause is meant any influence or impression which immediately and directly is instrumental in developing the phenomena of inflammation. To make entirely clear these definitions, I may adduce as an illustration the case of a person seized with paralysis of motion and

sensation,—a case of paraplegia. A change in the sensibility of the parts leaves them less able to endure pressure, and liable to become inflamed, to ulcerate, and slough. The paralysis is a predisposing cause; the weight of the body, or pressure, is the exciting cause.

PREDISPOSING CAUSES.—Among the predisposing causes which favor the development of inflammation may be mentioned,—

Temperament.—The constitutional peculiarities which form the basis of the so-called temperaments play a less conspicuous rôle now than in ancient times; but it is nevertheless true that these states of the body do incline to distinct forms of disease. An individual with a blood-vessel system surcharged with red blood, with a bounding heart, and with all the cell-changes of the tissues in a full tide of activity, combines in himself such vital conditions as predispose, from a very slight excitant, to inflammation of the pleura, lungs, stomach, or kidneys. An organization just the reverse—the lymphatic—is liable to disease of the joints or glands; and persons possessing an acutely-organized nervous system are frequently the subjects of intracranial and intraspinal inflammation, followed by serious disturbances of the locomotor apparatus of the body.

Hereditary influences.—Parents not only transmit peculiarities of family resemblance and moral dispositions to their children, but also a bias of organization, which disposes them to become victims of the most serious and distressing diseases, such as consumption, syphilis, cancer, gout, etc. It is just here that certain very grave moral questions arise touching one of the tenderest relations of life,—that of the marriage of parties with known transmissible diseases,—the ignoring of which, under such circumstances, involves a personal responsibility little short of actual guilt. One of the most difficult tasks is to obtain from patients a confession of any derived morbid proclivity; no one cares to acknowledge any defect at the fountain-head, as he is well aware that such an admission involves the purity of the stream. Some of these hereditary legacies crop out in early life, as scrofula and syphilis, and others much later, as gout and cancer.

Age.—Young children are particularly disposed to inflammations of the larynx, trachea, and meninges of the brain. Adolescence is liable to inflammatory affections of the glands, as the parotid in mumps, tonsils in quinsy, and the lymphatic in scrofula. Diseases of certain articulations, as the hip and the knee, giving rise to coxalgia and white swelling, are quite common at the same period of life.

The middle-aged are prone to pneumonia, rheumatism, bronchitis, and phthisis pulmonalis; and old age is subject to affections of the prostate body and bladder, and to various inflammatory changes of the heart and arteries.

Sex.—The sexual system of the female, subjected to the perturbations of menstruation and parturition, together with her sphere in social life, predisposes her to particular kinds of inflammation, such as peritonitis, mammitis, malignant and other growths.

Occupation.—All occupations, whatever they may be, incline, in some degree, to certain affections more than to others. Manufacturers of sand-paper suffer much from diseases of the air-passages, in consequence of the angularities of the siliceous particles with which the air is filled. I have been informed by the proprietor of one of these establishments that the mortality from this cause is very great. Those, also, who attend the modern threshing-machine, or who are exposed to irrespirable gases, suffer in like manner. The laborer, whose duties call him to wet or damp localities, is exposed to rheumatism, bronchitis, and pneumonia; the painter, to colica pictonum; and the student, or man of business, whose occupation is sedentary, is liable to derangement of the digestive apparatus, which of itself is a fruitful source of many inflammatory affections.

Habits.—The laws of health cannot be violated with impunity. Immoderate indulgence in the use of alcoholic drinks will favor disease of the stomach, liver, and kidneys; excessive venery, structural changes in central

portions of the nervous system; and neglect of cleanliness, multiform cutaneous eruptions.

Food.—This proves a fruitful predisposing cause of inflammatory disease. The gourmand who eats to repletion a rich stimulating fare, lays the foundation for disease of the stomach or liver. When of an improper kind, defective in certain components, as nitrogen, or in certain acids or alkaline salts, such as potash, it tends to the production of ulcerations, purpura, scurvy, and fevers of an adynamic type. The prolonged use of bread containing ergot may, by its effect on the muscular walls of the vessels, starve the tissues, which will so modify or disturb nutrition as to induce inflammatory changes. To food insufficient in quantity and imperfect in quality and preparation may be ascribed much of the disease among the poorer classes, especially during the summer season.

Temperature and locality.—The heat of summer of southern or tropical latitudes predisposes to disease of the liver and intestinal canal, while the rigor of high northern regions invites inflammatory trouble in the vocal and pulmonary organs. A most fruitful source of disease is that which arises from a residence in certain localities,—such, for example, as along stagnant water-courses or marshes, exposed to those miasmatic exhalations which poison the system and give rise to fevers and sequels of a grave character, as enlargement of the spleen, orchitis, etc.

The blood.—There are several ways in which the blood itself may predispose to inflammation. It may undergo such chemical changes as will favor the formation of thrombi and emboli. These obstructive masses arrested in the vessels and transported to the capillaries, where they become impacted, prove centres of inflammation. Again, when, from imperfect oxidation of nitrogenized matter, uric acid accumulates, there is a liability to gouty and rheumatic attacks.

Inflammation.—An attack of inflammation will often leave a part, from structural change, with diminished power to resist injurious impressions, and therefore prone to secondary attacks. A person who has once suffered from tonsillitis will be particularly open to similar invasions. The inflammatory changes which take place in important life-organs operate powerfully as predisposing causes to disease elsewhere. So we find diseases of the heart expose the lungs and kidneys to tissue-changes. In affections of the liver the vessels of the rectum become involved, producing hemorrhoids; in acute rheumatism, the endocardium; and in certain of the exanthemata, as scarlatina, the kidneys.

Undue functional activity.—There is a reciprocity existing between various organs of the body by which they can supplement or substitute one another. The skin in this way can do, for a time at least, the work of the kidney, or the kidney that of the skin. The extraordinary demands, however, involved in such a vicarious work tend to produce inflammation from the hyperæmia necessarily present. It is in this way, no doubt, that the suppressed secretion of the glandular apparatus of the skin disposes to nephritis; or, where the kidneys are disqualified to effect the elimination of certain products of textural waste, as urea, or uric acid, abscesses, boils, and carbuncles invade the surface of the body.

Excessive muscular exertion, exacting as it does heavy contributions from the nervous centres, may likewise provoke inflammatory changes in the medulla spinalis.

So also the eye, overtaxed by the long-continued inspection of minute objects, is liable to inflammatory disorders.

Mental and emotional states.—These form powerful predisposing and also exciting causes of inflammatory disease. Intense and protracted application to intricate subjects of study, by attracting an undue amount of blood to the brain, keeps up a habitual congestion, one of the elements in inflammation. Inordinate excitement opens the way for cardiac disease; sudden fear, overwhelming grief, the anxious watchings so often witnessed in the sick-room,

all exercise a pernicious influence on secretion and structural metamorphosis generally, through their depressing action on the nervous system, so that inflammatory explosions are favored from imperfect elimination or defective oxidation. Our insane institutions furnish many illustrations of the verity of these statements. Fear, grief, and joy must act through the eye and ear, organs of special sense, thus showing what a marvelous connection and interdependence exist between different portions of the nervous system.

Exciting Causes of Inflammation.—To attempt to enumerate every cause of this kind would be an endless task, for they are as varied and numerous as the objects of nature herself. Yet the subject may be simplified and order evoked out of the multitudinous and diverse causes by placing into groups or classes all such as sustain a particular relation to the body, or have a similarity of action.

The first division is into *external* and *internal* exciting causes. All agents which are without and independent of the body, and capable of exciting inflammation, belong to the external class; and all such as are directly or indirectly connected with the interior of the body or its components, acting locally or constitutionally, belong to the internal class. Each of these primary divisions admits of two subdivisions. They may be tabulated as follows:

$$\text{External Exciting Causes of Inflammation} \begin{cases} \text{Mechanical.} \\ \text{Chemical.} \end{cases}$$

$$\text{Internal Exciting Causes of Inflammation} \begin{cases} \text{Mechanical.} \\ \text{Chemical.} \end{cases}$$

External Exciting Causes of Inflammation.—Under this head are classed those which operate mechanically and those which operate chemically.

The mechanical causes are cuts, punctures, scratches, contusions, fractures, luxations, parasites, etc.

The chemical causes are caustics,—either acids or alkalies,—heat, cold, rubefacients, blisters, and other irritants.

Internal Exciting Causes of Inflammation.—These are likewise mechanical and chemical. Among the mechanical may be enumerated vesical, salivary, and biliary calculi, which, by movement, irregularity of surface, or enlargement, provoke structural change, not only in the parts with which they are in contact, but also in those quite remote. A stone in the kidney will, after long irritation, induce a cystitis, and a concretion in the gall-bladder, or in the common bile-duct, will excite peritonitis. Tuberculous deposition in the pulmonary tissue will determine localized pneumonia; necrosis of a bone, inflammation of the surrounding soft parts; embolism and thrombosis will produce a similar result in the blood-vessels and distant organs by obstruction; and large depots of extravasated blood, or even pus, the retained secretion of a gland, or pressure from morbid growths, may all provoke inflammation in the contiguous tissues. In regard to the last, the local irritation produced by growing tumors, nothing is more common than to find the neighboring structures blended together by inflammatory adhesions, and often greatly complicating operations for their removal.

Internal chemical causes are likewise numerous:

1. *Normal secretions of organs.*—The escape of bile through an ulcerated opening in the gall-bladder, or of the urine from a lesion in the walls of the urinary bladder, will excite a destructive peritonitis; or, if allowed to flow over the buttocks, will soon chafe the skin.

2. *Perverted secretions.*—The lachrymation from an inflamed eye, which runs over the cheek, will soon inflame and excoriate the skin; the secretion from the glands of the Schneiderian membrane of the nose under catarrhal irritation will do the same for the upper lip. The chemical changes which take place in the urine when the bladder is imperfectly emptied of its contents are, in time, almost certain to excite cystitis.

3. *Abnormal states of the blood.*—The blood determines inflammation after different modes. It may abound to such a degree in its normal constituents as to produce over-stimulation of the organs to which it is distributed: it is often the case that the brain, kidneys, and liver suffer from this cause. Or it may be deficient in these components, and unequal to supply the demands of the system, and so constitute a prolific source of disease. If we take a look at the background of metropolitan life, it is not difficult to understand the inflamed eyes, enlarged glands, and cutaneous diseases which abound on every side. The necessity for a varied and mixed diet in order to sustain the proper nutrition of the body is no longer a subject for discussion. The fearful ravages of scurvy, which has so often decimated ships' crews and armies, and the outbreaks of typhus among the starved soldiers of beleaguered garrisons, are sad illustrations of this statement.

The blood may be surcharged with the products of textural waste and become a tissue-poison. If from any cause there is an obstruction to the venous circulation through a part, and the blood is too long delayed, it becomes a local irritant. Such is the explanation of those inflammations which attack limbs in which the veins are in a varicose condition. Again, the blood may contain certain medicinal agents which by their presence excite inflammation. Turpentine and cantharides taken into the stomach or introduced through the skin in sufficient quantities will produce strangury, or inflammation at the neck of the bladder; mercury, inflammation of the salivary glands; certain preparations of potash, as the iodide, inflammation of the skin or mucous membrane of the nasal passages.

The entrance of pus or putrescent matters into the blood may be the cause of extensive inflammations, both by the arrest of the pus-corpuscle in the capillaries of the lung or liver, and by the change in its composition from the presence of spoiled serum or fibrin.

Again, the blood may be the recipient of certain subtle poisons of animal origin,—as in scarlatina, rubeola, smallpox, or syphilis,—introduced through the medium of the atmosphere, the point of a lancet, or sexual contact, which penetrate it like a leaven, and, after a period of apparent latency, cover the entire surface of the body with intense inflammation or disgusting crusts. Were it not that repeated observation has rendered it certain, it would be absolutely incredible that an emanation from the body of a person suffering from measles, so subtle as to defy careful scrutiny by the most powerful glasses and the most delicate chemical reagents, should so affect the entire mass of the circulating fluid through the partition-walls of the lungs as to involve the whole integument of the body, the conjunctiva, and the mucous membrane of the fauces and air-passages in a flame of inflammatory disease. There is something analogous to this in the cutaneous inflammation which attacks many persons who come within the atmosphere of certain members of the vegetable kingdom, as the Rhus toxicodendron. In the preference manifested by morbid poisons for definite districts of structure on which to expend their force, we see something akin to the elective affinities which rule in the domain of chemical action.

4. *Certain seasons of the year* determine particular inflammations. Thus, during summer, or the flowering period of grasses, many persons suffer from what is termed "hay catarrh," or a peculiar morbid state of the mucous membrane of the nasal passages,—whether from the pollen of plants, odoriferous emanations from vegetable growths, or peculiar electric conditions of the atmosphere, it is difficult to determine.

5. *Nervous influence.*—The agency of nerves, especially sensitive ones, in causing inflammation, is unquestionably very potent. The conjunctivitis and keratitis which follow division of the trifacial are examples in point. I have seen, following an injury of the median and ulnar nerves, a severe inflammation attack the hand, and in one case ulceration and necrosis of the proximal phalanx of the ring-finger, necessitating its removal. Similar cases were frequently witnessed in our military hospitals during the late war.

There is a discrepancy of opinion as to the manner in which such injuries provoke inflammation. Whether, as thought by Snellen, a part deprived of its normal sensibility is rendered helpless against mechanical and chemical influences of an injurious nature; whether the loss of control over the vessels of a part supplied by the divided nerve allows them to become surcharged with blood, which state of congestion determines the inflammation (an explanation harmonizing with the experiments of Graefe); or whether congestion is favored by the interruption of the ordinary nerve-influence concerned in the tissue-changes of nutrition, as held by Samuel, are all questions which admit of discussion. Snellen, after dividing the trigeminus in a rabbit, stitched the lids together, and also fastened the ears over the eye, yet he asserts that no inflammation ensued. Apparently this would prove that the eyelids protect the organ against inflammatory disease. Graefe, in order to determine their value in this particular, cut them away, together with the tear-glands, and yet the resulting inflammation from exposure fell short of that which follows division of the nerve. In facial paralysis I have seen the lids remain open for a long time without any result other than a slight redness of the conjunctiva. I believe, however, that all of these above-mentioned causes operate in developing inflammation; that is, the failure of the organ to recognize the presence of foreign matters, local hyperæmia, and disturbed nutrition.

Extension of Inflammation.—Inflammation, when once established, may be propagated in several ways:

1. *By sympathy.*—However obscure or difficult of explanation the fact, it cannot be questioned that a peculiar fellow-feeling exists between corresponding parts or organs of the body, so that when one suffers the other becomes likewise affected. The best solution of this problem will be found in the nervous distribution. On no other theory can we account for facts like the following. Rheumatic inflammation of the knee-, ankle-, or wrist-joint is frequently succeeded by the same disorder in the corresponding joint of the opposite side. Certain forms of skin disease make their appearance in this symmetrical manner. If one eye becomes inflamed, the other is liable after a time to suffer in the same way. Ophthalmologists understand this well, and, in cases where the eye first attacked is disorganized, or vision is hopeless, perform enucleation, with immediate relief to the other when it is inflamed. The same influence is exemplified in those cases of orchitis which follow inflammation of the parotid gland.

2. *By infection.*—Inflammation of the hand or foot is frequently followed by inflammation of an axillary or inguinal gland without any evidence of intermediate disturbance. It seems highly probable that in such cases some of the products of tissue-metamorphosis have been carried, through the medium of the lymphatics, to the glands in question. This is certainly often witnessed in the buboes which follow chancre or gonorrhœa.

3. *By the blood.*—The blood may propagate inflammation by carrying pus, emboli, or thrombi from a diseased point into vessels too small for their passage, and which from mechanical irritation become foci of secondary inflammation. Or, from a little pimple, the result of inoculation, it may disseminate something which will establish inflammation in many of the structures of the body.

4. *Continuity of structure.*—When inflammation, beginning at one point, continues to extend uninterruptedly over the same plane of tissues, or others adjoining, as we see a drop of water or ink spread over a sheet of bibulous paper, it is said to increase by continuity of structure. Some use the words continuity and contiguity to express two different modes of inflammatory extension. I can discover no distinction. The superimposed layers of structure are all really united by the small blood-vessels, nerves, and the accompanying threads of connective tissue. After this manner a urethritis becomes a cystitis; a pharyngitis becomes a laryngitis; a conjunctivitis, a keratitis;

or an erysipelas, a cellulitis. There are some who think that such a propagation of inflammation is the result of infection from textural death.

ACUTE INFLAMMATION.

The symptoms of inflammation are divided into the *local* and *constitutional*, —that is, such as are connected with the part inflamed, and such as belong to the system at large.

Local Symptoms.—These symptoms are change of *color, form, temperature, sensibility*, and *function*. In the main, this is only another way of expressing the compact formula of Celsus, written over eighteen hundred years ago: *Notæ vero inflammationes sunt quatuor: rubor, et tumor, cum calore, et dolore.*

Change of color.—This consists in increased redness of the inflamed part, and is seen of all shades, from the faintest red to a scarlet, purple, or bluish hue. The degree to which this sign is present will depend upon several conditions. The more acute, and, before any marked structural changes have occurred, the more pronounced, will be the scarlet color. The vascularity of the part inflamed will also have a determining influence on the degree of redness. Certain tissues are very rich in blood-vessels,—for example, the skin, conjunctiva, and, indeed, all mucous membranes; and hence the color in such, when inflamed, will be very red, while in those which are non-vascular or less abundantly supplied, as cartilage, the cornea, tendons, ligaments, arachnoid membrane of the brain, and other structures, it will be very faint, or only seen in the vessels contiguous to the part. The disposition of the color varies much in the inflammation of different structures. In that of the conjunctiva it is reticulated, corresponding to the network-like distribution of its vessels, or in conical eminences, answering to the papillary loops arranged over the palpebral part of the membrane. In the sclerotic it is in radiating streaks, and when in the iris it will often appear as a red zone at the circumference of the cornea, as if laid on with a brush. In certain cutaneous inflammations it will appear in points, spots, circles; or in crescents, as in rubeola. Sometimes it is diffused, and at other times abruptly defined. Sometimes it extends in long lines, as in inflammation of the superficial lymphatics, and at other times sends out blushing promontory-like arms with deep marginal indentations.

Again, the color is modified by the activity of the circulation. In inflammation of a carbuncular nature, where the tissues are dense and unyielding, and in which the inflammatory products are abundant, the vessels are so compressed that the blood makes its way through with difficulty, and, being long detained in the parts, assumes the character of venous blood. From this cause the infiltrated tissues are bluish at the centre, shading off at the circumference to a purple, or, if the obstruction is less and the circulation more active, a dull red.

When inflammation exists in a part in which the vitality, from injury or other causes, is very low, threatening gangrene, the color becomes dusky or reddish-brown. Cutaneous inflammations which arise from certain specific causes, as syphilis, possess a copper hue. It is no exaggeration to say that every grade and variety of inflammation has a characteristic color, which the trained eye of the physician will soon detect.

Redness, however, is not always a sign of inflammation: there is the blush which mantles the cheek from diffidence or shame; and a color that comes when the hot blood mounts to the face in anger or indignation. These are emotional results. Then there is the redness of the mucous membrane of the stomach and small intestine during digestion, or of a muscle in a state of contraction. Here it depends upon functional activity.

There is also redness from the application of rubefacients, as mustard, or stimulating liniments; from standing before an open fire, or exposing the face to a keen frosty atmosphere. In such cases it is due to irritation.

Again, there is a change of color seen in a part abnormally dependent, as

when the head is allowed to hang down, or when the circulation is embarrassed, as in croup or carcinomatous growths. In such the color may be red, purple, or tawny, and is dependent upon a mechanical impediment to the circulation. In these cases, for the most part, the color is temporary, transient, goes and comes, while that from inflammation is more permanent. When the redness is inflammatory, pressure with a finger will empty the vessels and make pale the part, but the moment that pressure is removed the color reappears; when non-inflammatory, the vessels fill more slowly. It often happens that the vessels of an inflamed part give way under the force of the circulation, and extravasation of blood follows. Such stains are not affected by pressure.

Change of form, or swelling.—The swelling of an inflamed part is due to several causes. First, to the increased amount of blood in the part; second, to the transudation and extravasation; and third, to the multiplication of organic forms or cells. The degree of swelling depends much upon the anatomical peculiarities of the inflamed part. Where the components are firmly bound together by inelastic connective tissue, it is scarcely noticeable. Where the connective tissue is abundant and loose, it will be very marked. Thus, an inflammation on the posterior part of the body, where the textures are dense, will be followed by less swelling than over the eyelid or the cheek, where they are very loosely bound together. In inflammation of bone the swelling will be altogether inconsiderable, as compared with that of the soft parts of the arm. The swelling is usually very great when mucous membranes are inflamed. In acute conjunctivitis the lining membrane of the eyelid will often protrude beyond the lid, as a red turgid mass (chemosis). An inflamed pile will acquire a great bulk in a few hours; the loose tissue at the top of the larynx or glottis may, from the same cause, swell so as to threaten suffocation, as in œdema of the glottis. The stream of urine may be much diminished in the same way in acute urethritis. All of these swellings depend upon the abundance of the submucous connective tissue. Where the inflamed part is deep-seated, below the deep fascia, the resistance of the latter prevents much external manifestation of swelling. Not always, however, is the distention noticeable even when the effusion is great. A synovitis may be followed by considerable fluid in the joint, and yet no visible signs of enlargement be present; the cavity of the pleura may be filled with serum and no bulging of the chest be observed; the Schneiderian membrane of the nasal passages may pour out an incredible discharge without materially encroaching upon the cavities of the nasal fossæ. The resisting walls of a joint and of the thorax, and the open surface of the mucous membrane of the nose, with its very sparse basis of connective tissue, explain these peculiarities. The swelling is circumscribed or diffuse, from three conditions: the consistence of the effused product, whether abounding in serum or in lymph; the close, compact arrangement of the parts of the tissue; and the manner in which the spaces, made by interlacing fibres, are filled by masses of fat. Fascial attachments also exercise a limiting influence, as when a fluid is below the supra-spinatus or the submaxillary fasciæ. Peculiarities of inflammation also determine the form of swelling, being limited in the furuncular and diffused in the erysipelatous variety. The form of the swelling often reveals its exact situation. The firmness of the tumefaction differs in different cases. It is sometimes quite soft, and is easily pressed aside by the finger, which, on its removal, leaves an indentation or pit; such a swelling is often called œdematous, the effused fluid being very frequently thin, serous, or watery, and the color white and waxy. Or it may be firm and unyielding to pressure, as is seen in erysipelas or carbuncle, in which case the transudation contains a large amount of fibrin, interpenetrating the components of the inflamed tissue. Occasionally there is a true hypertrophy and resistance, not from simple transudation, but from the development of connective tissue more or less matured. Such, however, is mostly met with where the active stage of the inflammation is overpast and the process glides into the chronic form.

In addition to these the swelling may be due to extravasation of blood or formation of pus. An inflammatory swelling may disappear rapidly or tardily. A large accumulation of serum in the cavity of the peritoneum, or in the cellular tissue of the lower extremities, may vanish in twenty-four hours, under a hydragogue cathartic or active diuretic. When the removal is rapid, the inflammation has passed its active stage, is subsiding, and the transudation consisting so largely of serum, and therefore being of little density, is readily absorbed, and its expulsion through the intestines and kidneys effected. Not so, however, with transudations of a more consistent nature, in which a large amount of organic forms and fibrin prevails. Here there must be retrograde metamorphosis, disintegration, decay, liquefaction, fatty transformation, etc., before the swelling can be disposed of; this is a work of time, and therefore more gradual and protracted.

Alteration in temperature, or heat.—When the hand is laid upon an inflamed surface, a sense of warmth is experienced materially greater than that of other portions of the body. The patient likewise is conscious of unusual local heat, and speaks of the part being hot or burning. The question has been warmly discussed, Is the heat of an inflamed part greater than that of the blood which circulates in it, say 98°?

John Hunter attempted to solve the problem by thermometry at St. George's Hospital. He laid open the tunica vaginalis for the cure of a hydrocele, and introduced a thermometer, which registered 92°. Inflammation was excited by packing the sack with lint, and again the bulb of the instrument was inserted, revealing a temperature of 98¾°. Though there was an increase of 6¾°, yet still it was less than the heat of the blood itself. This or similar experiments were frequently repeated, and uniformly with the same result. The difficulty in reaching the truth in this matter was due to the fact that, as in a room with an open fire-place, or containing a coil of pipe for the circulation of steam, there is a tendency to the establishment of an equilibrium of heat among the various pieces of furniture, so in the body the circulation of blood through a tissue tends to the same end; and secondly, to inability to construct such instruments as were sufficiently sensitive to appreciate the most minute quantities of caloric. That there is a certain measure of heat due to the amount of blood in a part, altogether independent of inflammation, cannot be questioned. I have several times repeated the experiment of M. Bernard, that of dividing the sympathetic cord in the neck of a rabbit, by which the external carotid vessels are paralyzed and rendered unable to regulate the amount of blood which fills their branches: the redness and the increase of temperature of the integument of the ear were quite apparent when contrasted with the corresponding part of the opposite side. The experiments of Mr. Simon with a thermo-electric battery, constructed by Dr. Edward Montgomery,* have furnished us with a definite solution of the vexed question. It was found that at the centre of inflammatory action the heat was greater than that of the arterial blood supplying, or of the venous blood leaving, the part,—and, further, that the venous blood possessed a higher temperature than the arterial. The conclusion was inevitable that this additional warmth must have been derived from the focus of inflammation. There is therefore the local evolution of heat in an inflamed part, and the correlative of this heat, in all probability, textural change.

Alteration in sensibility, or pain.—This symptom of inflammation is a sliding scale, and is present in all degrees, from mere increase of sensibility, or tenderness, to the most acute suffering. Usually its severity is in proportion to the intensity of the inflammation, reaches its height when the process is at its zenith, and diminishes or disappears as this process declines. It may be measured by the stages of the morbid action,—exquisite at the centre, becoming less and less as the circumference is approached. Most extensive inflammation may exist without the realization of pain. The pleural sac may be filled with serum and yet the patient never have been conscious of

* Holmes's Surgery, vol. i. pp. 18, 19.

any pain, or, at least, have had very inconsiderable sensations of it. Notwithstanding the extensive denudation of the intestinal mucous membrane in cholera, the patient may have suffered no abdominal pain: perhaps, as suggested by a writer, the cramps or spasms are its equivalent. The sensation of pain is due to injury sustained by the nerves of an inflamed tissue, which injury is not felt in the part, but is referred to it through the agency of the brain. This damage may consist in irritation, pressure, stretching, laceration, or disorganization of the nerve-substance. Its intensity is often conditioned upon the degree of structural resistance,—not upon the extent of the inflammation. A felon will produce more acute suffering than an inflammation covering the entire scalp; a toothache, more than a peritonitis; a circumscribed ostitis, more than a colitis. There is something peculiar in the insensibility of many internal organs. Most extensive inflammatory changes will take place in the liver, kidneys, lungs, brain, and spleen without the presence of pain; the soft texture, and, with the exception of the brain and kidneys, the elastic nature of their capsules, allowing the swelling to increase centrifugally, explain in part this circumstance. The fact that there may be serious structural lesions without suffering should keep the practitioner ever on the alert. While there are differences in the degree of pain, there are also differences in its kind. Every tissue complains in a way peculiar to itself. In the pleura it is lancinating; in the peritoneum it is extreme tenderness; in bone it is deep-seated, gnawing, and with frequently an evening exacerbation; in the testicle it is sickening; in muscular or fibrous tissue, as in rheumatism, it is dull, heavy; in the skin, burning or itching; in cancer, stabbing; and in parts firmly bound together, especially if dependent, it is throbbing, as in whitlow and hemorrhoids. Pain frequently induces violent reflex movements: a conjunctivitis will sometimes provoke spasm of the orbicularis muscle; a colitis, spasm of the levator ani and abdominal muscles; a cystitis, contraction of the muscular walls of the bladder; and a painful gum in a child will excite convulsive movements of the entire voluntary muscular system. In all these cases offensive impressions are made upon the sensitive nerves of the part, and these impressions are conducted to the spinal centre, from which come the violent movements through the motor branches.

Pain is not always felt in the inflamed part, but often quite remote from the seat of disease,—at the knee in hip-joint disease, at the end of the urethra in vesical calculus, and near the inferior angle of the scapula in affections of the liver. In inflammations of the organs of special sense there are phenomena of a peculiar kind, which may be considered as related to inflammations of these organs in the same way that pain is to other tissues. Such are the explosive sounds heard in the ear, the brilliant coruscations of light seen in the eye, and perverted olfaction in deep inflammations of the nasal cavities. Pain may exist without inflammation, as in neuralgia, and it is often a matter of the first importance to establish the diagnosis. When neuralgic it will be out of all proportion to any visible signs of textural change; shooting, or darting, in its character; in the course of well-recognized nerve-trunks; intermittent or periodical; frequently coming on in the fore part of the day and declining towards evening; often changing its seat, or going and coming at irregular intervals; and when near the surface frequently accompanied with distention of the contiguous veins. There is an abdominal pain, that of colic, which is not the pain of inflammation: it is relieved by pressure, and is intermittent, depending for its existence upon spasm of the muscular walls of the intestine, by which the nerves are compressed. The sudden cessation of pain often preominates mortification, especially when succeeding acute suffering, as in cases of intestinal disease followed by perforation; and if in addition there is present a frequent, feeble pulse, cold, clammy perspiration, hiccough, etc., it is still more diagnostic.

All persons do not suffer alike from this sensation. Some possess an organization so fine and delicately acute that the slightest scratch produces severe

suffering, while others cast in a ruder mould appear never to realize more than a little discomfort. Women endure pain with more fortitude than men. Deprecate pain as we may, it is an evil not without some compensation. It is the sentinel of the body posted at every gate to warn us of danger. A cramp in the stomach admonishes the gourmand of some imprudence in diet which must be corrected; a pain in the eye or head gives notice to the untiring student that both must have a season of rest; and the paroxysm of agony which announces the passage of a grain of sand along the ureter shows the necessity of at once correcting a vice which may lead to vesical calculus. On the other hand, when this sentinel is disarmed and unable to give the alarm, as in cases of paralysis, how often do we meet with extensive ulcerations from pressure, the patient being entirely unconscious of their existence! It is quite true that all the detailed phenomena of inflammation may be present and yet the condition not be one of inflammation, as in the everted eyelid of a crying child, in priapism in prolapse of the anus, or in the stomach during digestion. Most of these are examples, however, of great functional activity, but may, if too long maintained or overtaxed, lead to inflammation.

Alteration of function.—It is impossible that a part perturbed by causes which so profoundly affect sensibility, circulation, and nutrition should continue to execute its work in a normal manner. Alteration of function in inflammation may manifest itself in various ways:

1. *In supersensitiveness.*—This will often crop out before a single sign of inflammation can be detected. In incipient strumous ophthalmia, the eye becomes intolerant of light, almost photophobic, before a single line of color is discernible. In the developing stage of intracranial inflammation, the softest sounds will fall on the ear like the explosions of artillery. The bladder, upon the approach of inflammation, no longer remains a passive reservoir for the urine, but resists and expels it; and the stomach either refuses to do or performs imperfectly the work of chymification.

2. *Disordered secretion.*—The glandular secretions are changed in quantity. The salivary glands, when inflamed from the injudicious use of mercury, have their secretion greatly augmented; so also the glands of the nasal cavities, as in coryza. Secretion may likewise be diminished. Inflammation of the kidneys is followed by a marked falling off, and frequently complete suppression, of urine. This suspension of the secretory function prevents the elimination of those materials which, when retained in the blood, exert a poisonous influence on the system. The same is true of the bile in hepatitis. Secretions also undergo changes in quality, or chemical changes, from inflammation. The lachrymal discharge, which naturally is so bland and soothing to the eye, will become irritating; the mucous membrane of the bladder will react upon its contents, so as to change entirely the chemical constitution of the urine, and form combinations and deposits which greatly intensify its irritating properties.

3. *Imperfect or suspended function.*—If the eye is inflamed, the vision will often be defective, or disturbed by coruscations of light; if the ear, it will be rendered unfit to appreciate sounds correctly; in cerebritis, delirium and raving take the place of reason; in inflammation of the mucous membrane of the nasal passages, the sense of smell is, for a time, entirely suspended; and in glossitis the taste is temporarily lost.

Constitutional Symptoms.—I doubt not that in every case of inflammation, however insignificant or slight, the system at large realizes some disturbance, but like the influence felt from a pebble dropped into a lake, which, though affecting every drop of its water, yet is too inconsiderable to be detected by any of our present means of observation. When, however, the process is excited by some peculiar cause, as a puncture in making an autopsy, or when it involves a considerable surface of a particular portion of the body, as in erysipelas of the scalp, or when it occurs in peculiarly irritable individuals, a train of symptoms will be developed which will affect the entire

body. Nothing, perhaps, more forcibly illustrates the confederate bond or the organic unity of the human body than the general perturbation which spreads from local impressions, either morbid or healthful.

The constitutional disturbance following an operation or an injury is called surgical or traumatic fever, and is inflammatory in its nature,—a condition not recognized by the pulse or by the sensations of the patient alone, but by the elevation of temperature, which can be measured only by the clinical thermometer,—an instrument that should be the constant companion of the surgeon. This increase of temperature is always present in fever. Even when the patient complains of chilliness, or suffers from rigors, the thermometer may disclose a degree of heat greater than when his sensations are those of warmth. An elevated temperature—that is, above 98° or 100°—is always indicative of mischief, as it is an expression of tissue-destruction, the danger increasing with every additional degree, while its steady reduction augurs a favorable change in the course of the disease. We have, then, in thermometry a means of detecting the earliest approach of danger, and are thus prepared to meet it long before a single signal could be discerned in any other way accessible to the most acute observer. This fever which follows local injury, and which we call traumatic, appears, in part at least, to be due to infection; that is, the introduction into the blood of the products of textural change, rendering that fluid warmer, more irritating, and, in a measure, incompatible with the demands of the tissues through which it circulates. The changes wrought in the blood will be noticed when the intimate nature of inflammation is considered. Surgical fever, like that which is termed idiopathic fever, may assume a continued, remittent, or intermittent type, depending on causes which are entirely independent of the injury or operation. A patient with a compound fracture, if previously exposed to miasmatic influences, may, after the development of the inflammatory disturbance,—which, as a rule, is a continued fever,—be afterwards attacked with one of a remittent or intermittent form. If the patient is young, and possesses a sound, vigorous constitution, the course of the fever will be characterized by active symptoms; in other words, it will be acute or sthenic; but if he is feeble or has a broken constitution, one shattered by previous disease, privation, or abuse, its prevailing tendency will be adynamic or typhoid,—a complication which will add greatly to the gravity of the case. In persons with a predominating nervous system, the element of irritability may be added to those already existing. When the injury is followed by a profuse and protracted suppuration, hectic fever may follow, by which the danger is greatly enhanced. Sometimes, after traumatic fever arises, erysipelas will attack the injured part, and the whole drift of the disease will be changed from a dynamic to an adynamic form, in consequence of an additional element in the way of a blood-change; the same is true of surgical patients exposed to the vitiated atmosphere of an overcrowded hospital ward. Traumatic or inflammatory fever is somewhat irregular in the time of its appearance. It may arise within twenty-four hours, or it may be delayed for several days. In a case of amputation following a compound fracture, which I recently had under my care, it did not make its appearance until eight days after the operation.

There are various causes which operate to produce these differences, among which may be mentioned: shock, during which condition the circulation is in abeyance; local inertia, by which is meant an indolent, inactive state of the diseased or damaged part, such as we see where the arteries are in an abnormal condition; and structural peculiarities, some resenting violence more quickly than others, as, for instance, the peritoneum sooner than the parietes of the abdomen, and the scalp sooner than the cranium.

Inflammatory fever is wide-spread in its effects, disturbing the orderly operations of the entire body.

1. *The nervous and muscular systems.*—Previous to its development there

are often yawning and stretching, a period of lassitude and general muscular soreness, with pain in the loins, similar to the feelings experienced by one who has been engaged in a long and exhausting day's labor.

2. *The nervous and circulatory systems.*—There is next alteration in temperature: the patient experiences a sense of unusual warmth pervading the body, alternating with sensations of chilliness. If he changes his position in bed, or moves a limb, a rigor creeps over the body. The pulse becomes fuller and more frequent, rising from seventy-five (approximately its standard in health) to eighty-five, ninety, or one hundred or more beats per minute, sometimes full and bounding, at other times frequent and hard, or frequent and feeble. The pulse, it must be remembered, is modified by age, peculiarities of constitution, and the tissue or organ inflamed. These must all be taken into the account preliminary to the formation of a judgment. In young children, at least under three years of age, it will vary in health from ninety to one hundred and ten beats a minute; and therefore what is normal frequency in a child means fever in the adult. There are persons in whom the pulse is naturally very slow. A young man who was occasionally my companion in fatiguing shooting-excursions had a pulse which never exceeded thirty beats per minute, and his uncle, who was a physician, informed me that he had known it on one or two occasions to fall to sixteen beats. We generally associate a full, hard, and frequent pulse with acute inflammation in vigorous constitutions; and this is true when the supra-diaphragmatic viscera are involved; but when the stomach, peritoneum, or intestines are attacked, the artery will be small, tense, or corded, yet none the less indicative of the intensity of the process. There are also peculiarities incident to advanced life, such as diminished nerve-power with a feeble heart, in which we cannot accurately measure fever by the pulse, but only by the thermometer.

3. *The secretory system.*—The secretion of the various glands in inflammatory fever is also disturbed. The mouth, tongue, and lips are dry and parched with incessant and insatiate thirst. Thirst, which is so distressing a sensation in fever, is only a call for water upon the part of the tissues. Water is an essential requisite for those chemical changes which are ever in operation in the human body. The changes stimulated by the hot blood increase the urgency of this demand, so that the tissues become dry, and their capacity to absorb moisture is increased. Dr. Parkes, in his Gulstonian lectures on Fever,* advances the theory that in the tissue-metamorphoses induced by the disease, certain products are formed which may strongly attract water, such, for example, as some gelatinous body constructed from the albuminous matters of the blood, and this in turn may be converted into urea or uric acid, as gelatine always is when taken into the system, and thus eliminated from the body through the kidneys. In this connection the presence of sugar, which has so strong an attraction for water, and which is the cause of the thirst in diabetes, is brought forward to give plausibility to this ingenious explanation. Be this as it may, the folly of denying water to a patient consumed by febrile excitement must be apparent to every one.

To continue the detail of symptoms: the skin is hot and dry; the secretion of the kidneys is diminished in quantity and changed in quality, being high-colored and scalding. The urine is loaded with uric acid, rising, as found by Becquard, to 5.9 per cent. (the natural average being a little over 1 per cent.); the extractive matters are nearly doubled, while the fixed salts diminish about one-half and the chlorides in a still greater degree, that of sodium almost entirely disappearing during the acute stage. The biliary secretion is diminished, afterwards increased and changed in its constitution, as seen in the deep-green or tar-like dejections, which prove so acrid and irritating to the lower end of the bowel. The bile is sometimes returned to the blood, imparting a yellow or icterode tinge to the conjunctiva and skin. The tongue becomes covered with a white, yellow, or brown coat; the taste is perverted, the bowels are torpid, the appetite is lost, with perhaps a loathing for all kinds

* Medical Times and Gazette, vol. x. page 333.

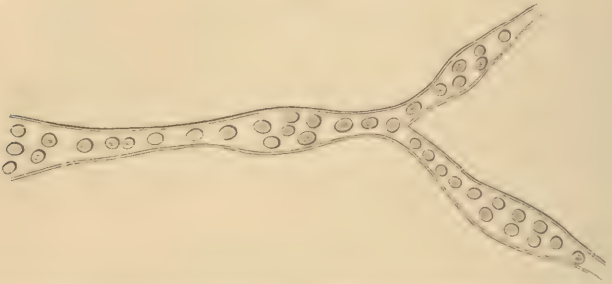
of food. The special senses become in some instances keenly acute, especially the eye and ear, so that all strong lights and sounds disturb and distress the patient. The sense of smell may become so extremely acute that odors which under other circumstances would not be recognized are decidedly offensive. There is fullness and pain in the head, with flushed face, and as evening approaches the restlessness increases, the respiration is more hurried, perhaps interrupted by sighs, the mind wanders, the sleep is uneasy, disturbed, broken at short intervals, and so the night is passed until the morning dawns, when the patient becomes more quiet and perhaps falls into a slumber, which may last for two or three hours. Not every case furnishes such a group of phenomena, either chronologically or numerically. The inflammatory fever may be so slight as scarcely to be observed, like a mere ripple upon the surface of a lake, or it may assume such violence that the strongest constitution will go down before the attack. The duration of these constitutional symptoms is not uniform; sometimes they pass away in a few hours, but again last for five or six days, during which time not only is the assimilation of food suspended, but the waste resulting from oxidation is increased, in consequence of which the patient emaciates. The subsidence is marked by general amelioration of all the symptoms, very much in the order of invasion. The restlessness and delirium pass away; the heart's action diminishes in both force and frequency; the skin becomes moist; a free perspiration sometimes breaks out over the body; the tongue loses its dryness; the thirst is diminished; the headache disappears; the urine becomes more abundant and deposits a lateritious sediment; the evacuations from the bowels assume a healthy color; the face regains a cheerful expression: in fine, so great is the change from the previous condition that the patient may be fittingly compared to a ship which has been driven and tossed for many days by fierce winds and tempestuous seas, yet has struggled on until the tempest is overpast and the anchor dropped in some quiet harbor.

Nature of Inflammation.—What is inflammation? We define a fracture to be a solution in the continuity of the fibres of a bone; a cataract to be an opacity of the crystalline lens, or of its capsule, or both. These are concise terms. But when we attempt to define inflammation by a few sharp, incisive words, we find ourselves surrounded by such limitations that any statement beyond a record of its phenomena is little more than conjecture. Indeed, in attempting to discover such a definition we are chasing a phantom. Like nutrition, the term inflammation is a generic one, and comprehends several very distinct series of phenomena. For their intelligent study we may arrange these phenomena under the following heads: 1, disturbed nerve-action; 2, disorder of the blood-vessels and their contents; 3, passage of the contents of blood-vessels through their walls; and, 4, change in the perivascular tissues of the inflamed part.

1. *Disturbed nerve-action.*—When an irritant, such as a drop of corrosive acid, or a hot iron, is brought in contact with the surface of the body, there is a consciousness of pain. This consciousness depends upon the presence of sensory nerves which have been damaged by the irritant, and which pass from the surface to a centre, the cerebro-spinal. Not only are impressions transmitted centripetally, but also, in answer to such, an influence is sent out along another line of nerves, which are centrifugal or efferent, and this influence produces muscular movement. The experiments of Claude Bernard, showing that from the sympathetic cord in the neck are derived nerves which control the superficial arteries of the head, constituted the initial step to other trials, which render it quite certain that the vascular system is under the regulating influence of a set of nerves, which together are called the vaso-motor system. These nerves are found to quicken and slacken the heart's movements; they regulate the size of the blood-vessels, and are also concerned in the process of secretion. While they all pass through the sympathetic, their origin is really in the cerebro-spinal centre. We have also

learned that arteries by virtue of such nerve-endowments execute rhythmical movements altogether independent of the heart, from which they are derived. (Fig. 1.) The receptive and executive centre of this vascular system of nerves has not been definitively determined, but there are reasons for believing that it is located in the upper extremity of the spinal cord, or perhaps

Fig. 1.



A minute artery, exhibiting several points of contraction independent of the heart's action.

in the entire cord, a view which receives support from the experiments of Dr. Nussbaum.* Excitation of these nerves occurs from either external or internal irritants, whether mechanical or chemical, and, I doubt not, forms an important antecedent to all the subsequent changes involved in the process of inflammation.

2. *Disorder of the blood-vessels and their contents.*—A few anatomical and physiological remarks in reference to a part of the vascular system will facilitate the study of this division of our subject. The circulation is effected by means of three kinds of vessels,—arteries, veins, and an intermediate set, the capillaries. The arteries and veins possess three coats. In the present connection the middle tissue has for us the greatest interest. It is composed of elastic tissue and unstriated muscular fibres arranged circularly. The relative proportion of these two structures varies at different portions of the vessels. At the root of the arterial tree,—the aorta,—there is little muscular with much elastic tissue, but as we approach the capillaries, and the vessels diminish in size, the muscular is largely in excess over the elastic element. In the veins the former structure largely preponderates at all points. Now, it follows that the arteries possess a physical property due to the presence of elastic tissue, and a vital property, that of contractility, due to their circular muscular fibres. The same may be affirmed of the veins, though to a different degree. From this organization the arteries are constantly acted upon by two distinct forces,—a vital one, which tends to lessen or close their canals, and a mechanical one, elasticity, which, together with blood-pressure, tends to enlarge or keep them open, so that during life they are ever oscillating between these antagonisms. It is this that produces the elliptical form of these tubes. (Fig. 2.)

Fig. 2.

Natural form of the canal of an artery when empty.

The nature of the capillaries is still a subject of discussion. By Leidesdorf and Stricker they are considered as homogeneous tubes of protoplasm, possessing the property of contraction; by His and Rouget, as formed between layers of cells and lined by an endothelium.

Dr. Woodward, Assistant Surgeon, U.S.A., in some very careful observations on the minute arteries, veins, and capillaries, was enabled, by nitrate of silver stainings, to demonstrate the existence of stomata or pores at the junction of the vascular endothelia. (See History of the Causes and Nature of Inflammation, p. 55, *post.*)

The behavior of the vessels and their contents under various excitants

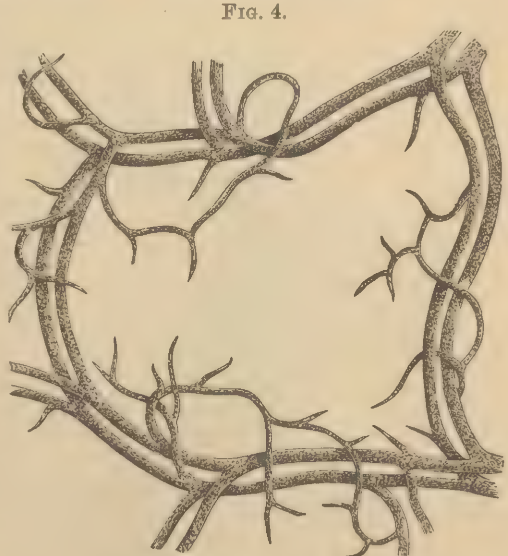
* Localization of the Vaso-Motor Centre, by Dr. Moritz Nussbaum, Archiv für Gesammte Physiologie, Med. Times, August 14, 1875, page 723.

has been carefully studied under the microscope by using the transparent tissues of animals, such as the mesentery, tongue, and cornea of the frog, or the wing of the bat. The first effect of the application of certain irritants is to induce a state of contraction, afterwards followed by dilatation, of the vessels, while by the use of others dilatation is immediately produced. From all the knowledge which we possess in regard to this alteration of size in the vessels of an inflamed part, it is highly probable that it is conditioned on the nature of the excitant. We certainly see this in the action of some drugs: ergot, for instance, will cause contraction of the arteries, while the nitrite of amyl will produce their dilatation. If such effects take place under circumstances other than inflammatory, it is not unreasonable to infer similar results from the action of those agents which provoke the disorder under consideration. Certain it is, however, that, whether the one or the other takes precedence, the final effect is dilatation. The diminution in the lumen or canal of a vessel is effected by contraction of its circular muscular fibres through the motor trunk of a vascular nerve, and is therefore an active condition; its dilatation, on the contrary, cannot be such, as there are no longitudinal muscular fibres, and when it exceeds that produced by the elastic tissue in its walls, it is the result of muscular enfeeblement, or paralysis. Coincident with the dilatation, which includes arteries, veins, and capillaries, the circulation becomes quickened, and the blood-corpuscles crowd into the vessels in large numbers, so as to make visible many channels which under other circumstances could not be seen: hence the redness or *rubor* of the affected part. No new vessels are formed, but the old ones are dilated, and, admitting files of red corpuscles, now become apparent. The experiments of Hunter and Paget strikingly verify this statement. That of Hunter consisted in injecting the two ears of a rabbit, in one of which inflammation had been produced by freezing. The contrast between the healthy and the unhealthy one is shown in Fig. 3. Those in the left appear to be much more numerous and tortuous than those in the right ear. The experiment of Paget was made on the wings of the bat (Figs. 4 and 5), inflammation being excited in one by means of the cautery. The vessels increase not only in width,

FIG. 3.

The different vascularity of the two ears in a rabbit in which Hunter's experiment has been performed.

FIG. 4.



Uninflamed wing of the bat. After Paget.

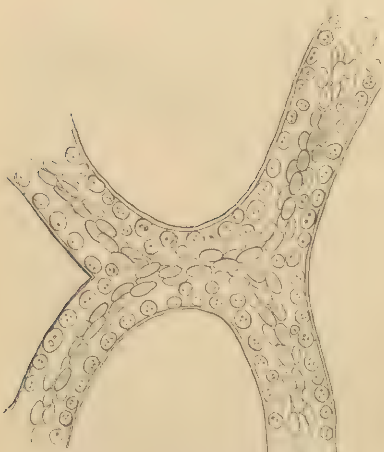
but likewise in length, which gives them a serpentine, tortuous, and even varicose appearance.

The dilatation begins in the arteries, and afterwards extends to the veins. The acceleration of the circulation, on the supposition that the action of the heart and the resistance of the capillaries remain unchanged, cannot be attributed to the alteration in the size of the vessels. On the contrary, we should expect the reverse to be true,—namely, a diminished rapidity in the movement of the blood, just as streams travel at a slower rate after passing from narrow into more expanded channels. On every side and for some distance around, the blood is seen streaming in towards the focus of irritation, and crowding the vessels with corpuscles. It is to this circle of rapid movement that the term *determination* applies, and it gives a plethora to the vessels some distance beyond the immediate area of inflammatory action. After a time another change takes place. The movement of the blood becomes slower; the red corpuscles, closely packed together, are disposed to cohere, and to occupy the central axes of the vessels. This tendency in the red corpuscles to cling to one another is not in any way peculiar to inflammatory blood, for the same behavior is observed in healthy blood which has escaped from the vessels. This slowing of the circulation when observed under the microscope is exceedingly interesting. At one point a group of red corpuscles is seen rolling along, then stopping, and again moving forward with apparent difficulty; at another, a few adhering corpuscles attempt the passage of a capillary channel and fail, then retrograde and again charge the obstruction, sometimes with, at other times without, success. In another part of the field a mass of corpuscles appears to have become arrested in the vessel, when others moving rapidly forward against the barrier set them free by the impulse, or, failing in this, whirl off into other channels where the obstacles are less formidable.

Fig. 5.

Inflamed wing of the bat.

Fig. 6.

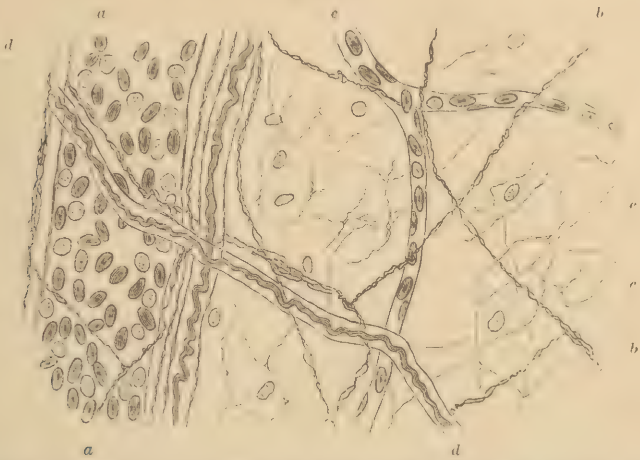


The position occupied by the red and white corpuscles.

This circle of diminished activity in the flow of the blood is what is termed *congestion*. It has been said that the red corpuscles select the centre of the vessels, thus leaving a space between them and the vascular walls which is occupied by white corpuscles (Fig. 6), the number of which appears to have greatly multiplied. These corpuscles, or leucocytes, seem to have a strong attraction for one another and

for the walls of the vessels, to which they are disposed to adhere, their movements being much less rapid than those of the red. As the process advances, the crowding of the vessels with corpuscular bodies reaches its limit, so that at and for a short distance around the focus of inflammation the blood-movement ceases: this state constitutes *stagnation* or *stasis*. Nothing can more beautifully illustrate the difference in numbers of the red and white corpuscles, and their relation to one another, and to the walls of the vessels,

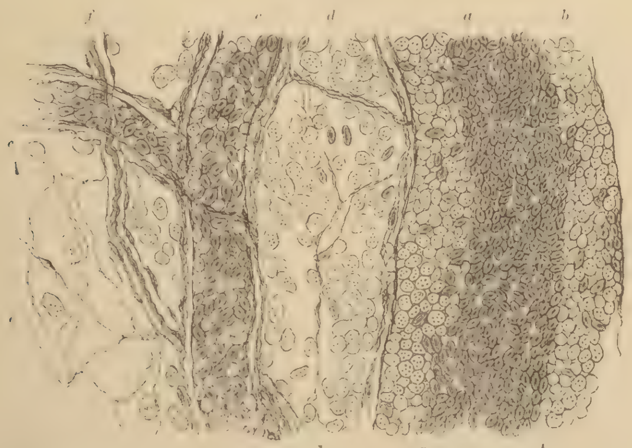
FIG. 7.



Non-inflamed mesentery of the frog, 400 diameters, reduced ½: *a*, *a*, venule with red and white corpuscles; *b*, *b*, gelatinous nerve-fibre; *c*, capillary; *d*, *d*, dark-bordered nerve-fibre; *e*, *e*, connective tissue with connective-tissue corpuscles and leucocytes scattered sparsely through it.

in the uninflamed and the inflamed state, than Figures 7 and 8, showing the circulation in the mesentery of the frog under these two conditions, and which

FIG. 8.



Inflamed mesentery of the frog, 400 diameters, reduced ½: *a*, *b*, venule filled with red and white corpuscles; the red in the centre and the white crowding along the walls; *c*, *c*, capillary distended with red and white corpuscles; number of the white much increased; *d*, *d*, connective tissue between venule and capillary filled with migrated leucocytes; *e*, *e*, connective tissue with less infiltration; *f*, dark-bordered nerve-fibre; *g*, number of nuclei in sheaths increased.

are faithful representations, drawn from nature, under the camera of the microscope, by Dr. E. O. Shakespeare.

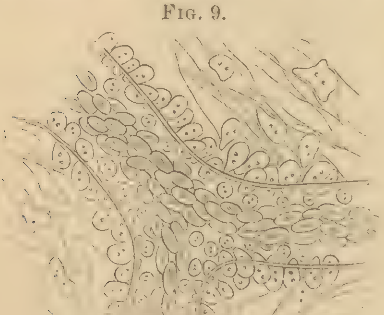
We have thus advanced three stages in the process,—determination, con-

gestion, and stagnation. The different phenomena remind one very forcibly of a crowd of living beings in a great city, attracted towards some scene of excitement. On every side, along every street, lane, and alley, men, women, and children are seen running in hot haste, their faces all turned towards a common point: this is determination. As this central point is neared, the crowd is so closely collected that movement becomes slow and difficult, and the pace is slackened; some turn off in one direction, others in a different one; some retrace their steps, and others press their way forward, jostling their neighbors without formality: this is congestion. Still farther inward, at the very focus of attraction, the throng is so densely packed that movement is impossible: this is stagnation.

At the seat of stasis, or rest, the capillaries appear to be densely packed with red corpuscles alone, altered in form and apparently without any liquor sanguinis. The cause of this stasis is, according to Ryneck of Grätz, due to a change in the vital properties of the capillary walls: the ground for such an opinion will presently appear. But perhaps the most astonishing part of this process is that which takes place with the slowing of the blood, —namely, the passage of the latter from the interior to the exterior of the vessels.

3. *Passage of the contents of the vessels through the walls.*—Various terms are employed to express this change of place of the vascular contents, such as "effusion," "exudation," and "migration." I prefer and shall use the word *transudation.* There is a normal transudation which is constantly in operation to supply needful demands of the tissues: it is this which gives to the latter their moisture or succulence,—a kind of nutritive bath. The inflammatory transudation differs chiefly from the normal in a marked increase of the constituents of the liquor sanguinis, as well as in a larger number of corpuscular forms. It may occur from mechanical causes, altogether independent of inflammation, as when a group of indurated glands press upon the axillary vein, or the gravid uterus upon the cava or iliac vessels, obstructing the return current of blood, in consequence of which the liquid portion finds its way through the porosities which, if it be true that physical particles are never in absolute contact, must exist in the walls of the vessels. The anasarca from hepatic and cardiac diseases is also of this nature. A familiar illustration of this can be witnessed in the leather hose of the firemen: under the pressure of the column of water the whole extent of surface sweats with moisture which has been pressed through its pores. This will not, however, account for the escape of the corpuscular part of the blood. The white corpuscles, or leucocytes, which linger about the sides of the vessels, begin to penetrate their walls. They are seen to disappear gradually from the inside, and to appear on the outside, in the form of button-like prominences, or partly in and partly out of the vessel, in dumb-bell forms; these become pyriform, then remain attached by a delicate thread, and finally are entirely disengaged (Fig. 9), to wander off among the perivascular structures, by the amœboid movements with which they are endowed. This passage is called a *migration.* Not only do leucocytes wander out of the vessels, but to some extent also the red corpuscles. The manner in which this is effected is believed to be through minute stomata which exist on the minute vessels along the lines of junction between the cells of their endothelium. It has been objected that these stomata, many of which do not exceed one ten-thousandth

Fig. 9.



Migration or transudation of leucocytes, or the passage of white corpuscles through the walls of the vessels.

of an inch in diameter, are entirely too small to admit the passage of a white corpuscle, a body averaging about one three-thousandth of an inch in diameter. Such an objection is without force when we consider the extraordinary change of form which the leucocytes undergo, and the not improbable dilatability of the stomata themselves. Others, regarding the capillaries as consisting of protoplasm, do not deem the presence of stomata at all necessary to the migration, but simply contact of the protoplasm of the vessels with that of the white corpuscles, by which the walls open, and again close behind the leucocytes as they escape. The experiments of Ryneck show pretty conclusively that stomata exist, and that the act is a chemico-vital one, in which the walls of the vessels play a prominent part. By displacing the blood of curarized frogs and injecting in its place milk or defibrinated blood, and then irritating the mesentery, he was enabled to produce promptly the phenomena of determination, slowing, and transudation. Using a solution of common salt to replace the blood, and then introducing a solution of chromic acid, or the sulphate of copper, so as to damage the vital properties of the walls of the capillaries, he found, upon transfusing with the milk or defibrinated blood, that neither stagnation nor transudation followed. There can be little doubt that the minute blood-vessels, which constitute a great irrigating net-work, sustain a relation to the work of nutrition which gives them an importance very different from that of the larger arteries and veins. They are indeed living tubes, and not simply canals of conduction.

The blood undergoes not only a change of place, but also a change of constitution, which will be best understood by a comparison of its physiological and pathological characteristics. It is normally a very changeable tissue, and if a hundred analyses were made of the blood of the same individual, at a hundred different periods, no two would agree in all particulars. Still, this does not materially affect the comparison between inflammatory and non-inflammatory blood. The red and white corpuscles, when in physiological harmony with the demands of the tissues, bear a certain numerical relation to each other; that is, they are in the proportion of about four hundred red corpuscles to one leucocyte. It is true, some modification of this statement must be made in the case of the veins of the liver and spleen, in which the white corpuscles are much more numerous; and the same is true after a full meal. These corpuscles, again, in health are indiscriminately intermingled, and glide along without showing any disposition to loiter by the way. Now, in inflammatory disturbances of the blood-vessels the normal proportion is changed: the white corpuscles are increased in number, and remarkably so in inflammations of certain organs, such as the spleen and lymphatic glands, so as even to form one-half of the corpuscular part of the blood. As the red corpuscle is probably formed from the white, the cause of such increase would seem to be an arrest in the development of the latter. Again, in inflammatory blood, as has been stated, instead of moving promiscuously through the affected vessels, the corpuscles assume somewhat distinct positions, the red in the centre, and the white along the sides.

The transudation, in addition to leucocytes, consists of liquor sanguinis. This fluid, however, as found in the inflamed tissue, possesses certain notable chemical differences from that of uninflamed blood, which appear to have been acquired during or after its passage through the vessels. The liquor sanguinis of normal blood contains a large amount of albumen,—about one-tenth. A portion of this, when drawn from the vessels, undergoes quickly spontaneous coagulation, forming fibrin. It is the latter which produces the coagulation of the blood, forming a porous, gelatinous mass, or clot, in the meshes or interstices of which are entangled the corpuscles. If the coagulation takes place slowly, the corpuscles have time to sink to the bottom of the clot before being caught, which leaves its upper portion colorless, and forms what is known as the *buffy coat*. This upper part, wanting the resistance of the corpuscles, contracts more than the lower, so that the clot finally assumes the form of a truncated cone, the edges and upper surface of which,

continuing to contract, give to the solidifying mass a concave or *cupped* shape (Fig. 10). In inflammation the fibrin is greatly increased, even to the extent

FIG. 10.

Section of a blood-clot, the corpuscles having been washed out, leaving a sponge-like mass of fibrin; the upper surface showing the cupped form.

of three or four times the normal amount, as in cases of inflammation of the lungs and serous membranes, and in proportion to the increase is the extent of the buffy coat. How fibrin is formed, and what is its relation to nutrition, are questions which physiology has not as yet answered. As a concrete substance, it does not exist in the blood; it only becomes so after leaving the vessels. We have various theories explanatory of its formation, from the action of paraglobulin on certain albuminoid or fibrogenous substances, or from a substance which Schmidt and Dennis call *plasmine*, and according to whom the variations in the amount of fibrin in coagulated blood are due to a decomposition of this plasmine unequally into "concrete" and "dissolved fibrin." When, however, we consider that the fibrin is increased by bleeding, and by starvation; that the blood of the hound or of the horse yields it in larger quantities after than before the chase or the race; and that, as shown by the experiments of Brown-Séquard, it is increased by muscular action,—it appears most reasonable to regard it as excrementitious, or a product of tissue-waste, and therefore more naturally associated with destructive than with constructive processes. It seems to me that this substance, which takes no part in organization, has, nevertheless, a very important office,—one not unlike that of the scaffolding and temporary arch-supports of a building,—thus supplying a frame-work for the support of those organic forms which are immediately concerned in tissue-construction, and which, when this is sufficiently advanced, disintegrates and is removed, just as the scaffolding and arch-supports are taken down when the building is completed.

The serum of the blood, the watery fluid in which the clot floats, contains in solution albuminous substances not spontaneously coagulable, and different saline ingredients, the latter making as much as ten parts in the hundred. Now, in inflammation there is a change. The albumen, phosphates, carbonates, and chlorides, especially the chloride of sodium, are largely increased. Beale states that in inflammation of the lung the organ becomes loaded with the chloride of sodium, while it disappears almost entirely from the urinary secretion.

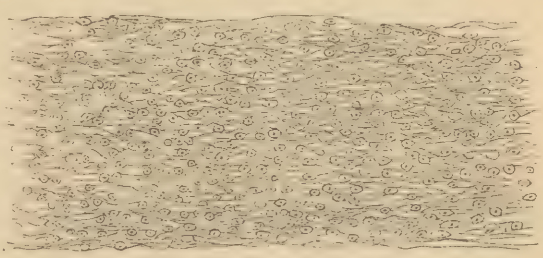
Still, there is no constant uniformity in the constitution of inflammatory transudations. Sometimes they are quite fluid, possessing little fibrin, and exhibiting no tendency to organization, as when a rapid transudation follows inflammation of the pleura, forming a hydrothorax in one person, while in another a few hours will be sufficient to glue the contiguous layers together

by a bond of fibrin. Or, we may have in one case a transudation into the cavity of a joint, as thin as water, which never assumes the importance of an organized tissue; while in another, fibrous bands are formed, which produce a form of anchylosis. Paget recognized two kinds of transudation: one tending to adhesion or organization,—fibrinous lymph,—and the other to suppuration,—corpuscular lymph; the first rich in fibrin, the last in corpuscles. In inflammatory irritation of mucous membranes—catarrh, for example, of the nose—the transudation may be thin and watery, a mere exaltation of gland-function, or hypersecretion, with rapid epithelial detachment; or it may be purulent, in which case there will be an active proliferation of the protoplasm of the deep layer of the epithelium and transuded or migrated leucocytes; or it may assume the consistence of a false membrane, as in croup, spreading over the surface of the trachea, adapting itself to every inequality of its surface, and made up of a stratification of solidified fibrin with interposed and interpenetrating cells.

These transudations, again, are often modified by the products of textural change, intermixed with particles of disorganized tissue, such as shreds of the fasciæ, lime-salts, fatty matters, and blood-corpuscles. These masses of blood, which are so often seen in transudations, occur from two different causes: in one, these corpuscles are present by migration, whilst in the other, they are present from actual rupture of the overstrained vessels, and form, therefore, a hemorrhage or apoplectic extravasation.

The escape of the transudation is followed by *infiltration.* Both the liquid and the corpuscular constituents which have thus escaped from the vessels spread through the perivascular structures (Fig. 11), finding their way into every crevice and space, and interpenetrating often the finest components of an organ, wedging them asunder, crowding and compressing nerves and blood-vessels, and thus giving rise to pain or preventing access of the blood to or escape from a part, in many cases inducing a wide-spread devastation of structure. This infiltration spreads from the operation of several causes, such as the impetus communicated by the intravascular pressure, gravitation, and the locomotor or amœboid endowments of the corpuscles. It is this infiltration which chiefly gives rise to the swelling in inflammation, and upon its quality will depend the consistence of the intumescence. When very thin and watery it will be soft, as in œdema, but when possessing much fibrinous matter it will be firm and resistant.

FIG. 11.



Inflammatory infiltration.

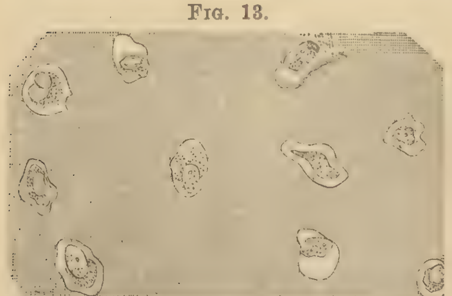
4. *Change in the nutrition of the perivascular tissues.*—Thus far we have been occupied with nerves, blood-vessels, and the blood: but we have now to consider the influence of inflammation upon the tissues external to these. Whenever a part is invaded by a transudation of inflammatory liquor sanguinis it is the signal for an extraordinary degree of cell activity. Whence come these cells, and what is their origin, are questions which have received especial attention. Is their presence due to the germination or proliferation of those which normally belong to the inflamed tissue, stimulated into reproductive activity by the influence of the transudation upon their quiescent protoplasm, or do these cells come from abroad, as emigrants which have wandered out of the contiguous vessels, and, vandal-like, have overrun the tissues? Both views have their advocates. The non-vascular tissues, with a view to determine this problem, have been selected as peculiarly adapted to such study. The most conclusive of these investigations are those made by Professors

Norris and Stricker,* at the Institute for Experimental Pathology in Vienna, on the subject of traumatic keratitis produced in the cornea of the frog. That the bearing of these may be properly understood, it may be necessary to state that preparations of this structure should be made after the method of Von Recklinghausen, which consists in immersing the cornea, with its lining membrane upward, in a few drops of the aqueous humor drawn from the eye, and examining under circumstances which will prevent evaporation,—that is, in a chamber where the air is surcharged with moisture. Under such circumstances the cornea appears to be entirely homogeneous, without the least evidence of structure, and is therefore admirably adapted for the transmission of light. As soon as its vitality begins to decline, the structureless character is lost, its epithelial cells, leucocytes, and corneal corpuscles become visible, and the membrane a little less transparent. In the experiments alluded to, it was found that very soon after the application of a point of nitrate of silver to the cornea its structural elements became apparent,—namely, the epithelial layer, together with a number of white corpuscles,—and still later the cornea corpuscles with their nuclei and radiating processes were visible. Not only so, but the peculiar amœboid movements were observed. Thus far it was quite apparent that the protoplasm of these inert, dormant masses of formed material had been penetrated by some new revivifying force. (Fig. 12.) In addition to the phenomena just detailed, other round bodies besides the nuclei were seen lying in the centre of the corpuscles, foreshadowing the future proliferation or multiplication of cell forms. Following the process further, a few hours later many of the corpuscles were found to have undergone another change,—that is, they became granular, at the same time retracting their rays,—and this continued until these processes entirely disappeared, and nothing was seen within the field of view but multiform, irregular-shaped masses, containing a brood of new cells. (Fig. 13.) Still later the multiplication of these bodies became more and more apparent, and after the lapse of twenty-four hours the increase of new forms was so rapid that the whole tissue became clouded and inundated with their presence. (Fig. 14.) At the beginning but few leucocytes were visible, but at the stage just described their numbers had become countless, and suppurative keratitis was established. What interpretation shall we place on these phenomena? Whence came this flood of leucocytes, rendering the structure so opaque? Certainly not from the few cells native to the part; not by emigration, for there were no vessels in the cornea whence they

Fig. 12.

Cornea of a frog three hours after its removal: showing the corpuscles with their rays and the round masses lying in their bodies after irritation with nitrate of silver.—From Norris and Stricker's Studies.

Fig. 13.



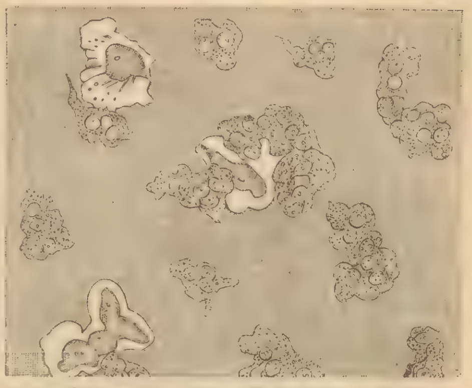
Irregular-shaped masses containing broods of new cells.

* Versuche über Hornhautentzündung, von W. F. Norris und S. Stricker, Wien, 1869.

could come: we are forced to the conclusion that they originated chiefly from the corneal corpuscles by proliferation, and also from the few progenitors existing in the part.

On the other hand we have Cohnheim, whose views do not accord with these observations. He maintains that the leucocytes, or pus-corpuscles, which appear in corneal inflammation are all emigrants, and that the normal corpuscles do not in any way participate in or contribute to their supply. Burdon Sanderson states that Cohnheim's observations on traumatic keratitis began at a point of time where those of others ceased. This would disqualify him for pronouncing upon the earlier changes in the histological elements of the structure.

Fig. 14.

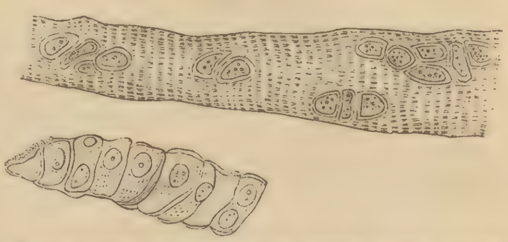


Cornea of a frog sixteen hours after irritation: showing the numerous groups of new cells.

In cartilage we have phenomena resulting from irritation which furnish still stronger evidence that emigration is not exclusively the source of pus-corpuscles, as the cartilage-cell buried in the intercellular matrix under traumatic stimulation enlarges, becomes granular, and, by division of its nuclei, filled with crowds of new cells, answering to pus-corpuscles, and which subsist upon the intercellular substance, giving it a worm-eaten or porous appearance. Cartilage, indeed, formed the subject of the first experiments which were made to show the division of cells as the result of inflammatory irritation, by Redfern, of England. The vascularity of connective tissue renders it difficult to determine, in consequence of the rapid emigration, the exact behavior of its stable or fixed components; but the patient observations of Stricker prove that under irritation they swell, become mobile, and send out processes; and although he was not able to say that he witnessed their actual division, yet in the activities noted it was difficult not to believe that they contributed their part in the formation of pus, though, perhaps, generally at an advanced stage of the process.

The experiment of Prof. Lortet, of Lyons, illustrates in a very simple manner the conjoined participation of emigrant and connective-tissue corpuscles in the production of pus. It consisted in introducing into the cellular tissue beneath the skin of a rabbit the swimming-bladder of a fish, containing a solution of salt. When removed after several hours, it was found full of emigrant cells, which of course must have come from the vessels, but, in addition, the corpuscles of the surrounding connective tissue were in a state of active cell proliferation.

Fig. 15.



The protoplasm of the fibre-sheath connective-tissue corpuscles becoming active, as seen in the multiplication of nuclei.—From Norris and Stricker's Studies.

The effect of inflammatory irritation on muscular tissue has been studied by Waldeyer, Weber, Stricker, Simon, and Tschainski, the result of whose investigations appears to establish the fact of the germination of the connective-tissue or stable corpuscles of the finer ramifications of the sheath and the intrusion of wandering cells. (Fig. 15.) These cells, in all

probability from these two sources, finally become so numerous that they take the place entirely of the sarcous elements; that is, they not merely displace, but really destroy, the muscular substance contained in the fibre-sheaths. (Fig. 16.) Examples of such changes are often seen in the muscles in the vicinity of an old necrosis, where the long-continued inflammation has left little else than fibrous tissue, oil-drops, and cell forms.

Bone, also, hard and unyielding as it is, when attacked by inflammation undergoes nutritive changes very quickly. Its canals enlarge, becoming filled with cells: some from the vessels of the Haversian and medullary canals, and others from the myeloid cells of the medulla. These exacting organisms compel a separation in the animal and earthy constituents of the structure, which are in a great measure removed by mechanical and chemical transformations, giving to the bone a porous, gnawed, and worm-eaten appearance, and making it so brittle as to break down under the slightest pressure.

FIG. 16.

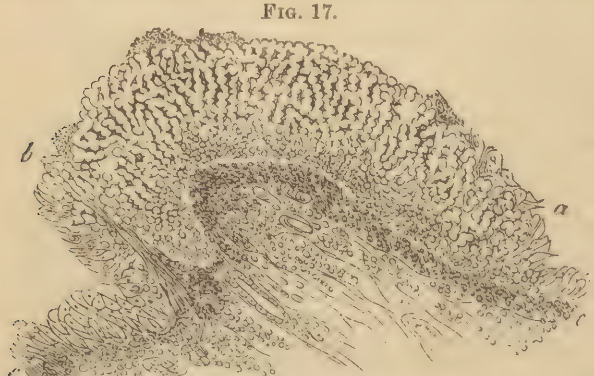
Transverse section of an inflamed muscle. The dark, irregular masses represent bundles of muscular fibres changed; while the other parts show two fibre-sheaths completely occupied by cells having displaced sarcous matter, and the intermediate connective tissue filled with crowds of proliferating cells.—From Weber.

Blood-vessels, when falling a prey to inflammation, exhibit great numbers of cells, which are derived from their nutritive branches and penetrate the inner tunic, with others which have their genesis in cells of the coat itself.

When glandular organs become inflamed, the same increase of corpuscular bodies is witnessed. And it is to be inferred that these have three origins or sources: viz., from the cells of the gland; from migration; and from the stable connective-tissue corpuscles of the gland.

In the inflammation of mucous membranes, the epithelial and mucous cells not only increase by multiplication, but wandering cells appear in great force. In the fauces, as shown by Rindfleisch, the entire formation consists almost wholly of cells linked to one another by outgrowths, and which, together with a change in their protoplasm, form a closely-set net-work. (Fig. 17.) So in the false membranes of the trachea, which prove so mechanically obstructive to respiration, the same abundance of cell forms is seen reposing upon and interpenetrating fibrinous planes of transudation. In inflammatory, purulent, or other catarrhs of mucous membranes, we have illustrations of multiplied cell forms, whatever may be their origin (Fig. 18), though perhaps in the earlier history of such, the increase may be referred more to proliferation than to emigration.

FIG. 17.



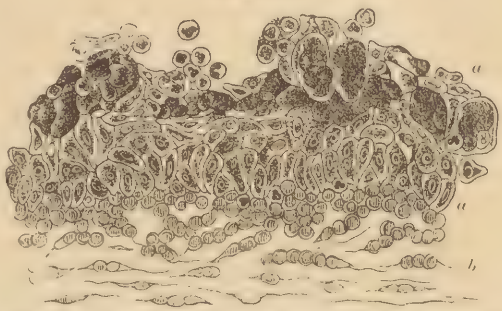
Section of the croupous layer from the fauces: *a*, *b*, croupous membrane made up almost wholly of cells with processes forming a cell net-work; *c*, natural mucous membrane underlying.—From Rindfleisch.

Serous membranes, under the influence of inflammation, exhibit great activity in the protoplasm of their epithelial cells, and abound in wandering leucocytes, which, supported in a scaffolding of fibrin, pass, with the peculiar

intercellular material present, from the mobile to the fixed or stable condition, forming connective tissue, and so become a bond of union between contiguous surfaces, or, when not in contact, produce a kind of fleecy or frost-work pile over the surface.

Thus we see that inflammation, wherever found, is characterized by extraordinary cell activity both in those elements which are native and in those which are foreign to the tissue involved; that the cause of this activity is the abundant transudation; that the cause of the abundant transudation is an extraordinary amount of blood, and a vital change in the walls of the capillaries, allowing the blood to pass through; and that the cause of this unusual amount of blood and its transudation is an irritation, either external or internal, acting upon the walls of the vessels through a vascular system of nerves.

Fig. 18.



Purulent catarrh of the conjunctiva: *a*, *a*, epithelium; *b*, submucous connective tissue; the outermost cells are pus-cells.—From Rindfleisch.

In normal nutrition, the want of the tissues—that is, their demand for nutritive material—is communicated to the blood-vessels through the vaso-motor nerves. It is a kind of irritation, and it is this gentle, ever-acting stimulus which secures the due amount of blood-supply; transudation both of liquid and of formed material is ever going on to meet it, and there is a constant decay and renewal of cell life.

The more carefully we analyze and compare the phenomena of normal nutrition and inflammation, the more we are disposed to formulate them into a single, compact statement, and conclude that inflammation is hypernutrition carried on under such an extravagant plenum of supply that the germination and mutation of cell life are generally too hurried to mature, and are therefore unstable and short-lived.

History of the Causes and Nature of Inflammation.

The student of the present day finds himself pressed on every side with the facts of the living present, and rarely finds leisure to trace back over the centuries the stream of medical literature: therefore it may not be amiss to make a rapid review of the theories which have at different periods been entertained upon the subject of inflammation. Hippocrates, who lived four hundred and sixty years before the Christian era, believed that this, with almost all other diseases, was produced by changes in the humors, which he styled *coction*, such as the lateritious deposits in the urine at the termination of a paroxysm of fever.* Erasistratus, who flourished one hundred years before the same era, a man of remarkable ability and independence of thought, offered a different explanation, originating, no doubt, in the erroneous notions entertained in regard to the circulation: "Should the air coming from the heart force the blood back into the extremities of the arteries, it becomes impacted there and produces inflammation." Celsus,† cotemporary with Christ, confined himself to describing the symptoms of inflammation and its treatment, and was the author of the celebrated formula, "Rubor et tumor, cum calore et dolore." Galen, the greatest of the Greek physicians after Hippocrates, and who died about two hundred years after Christ, used very much the same terms in describing the phenomena of inflammation as those

* Works of Hippocrates, Syden. Soc. Ed., vol. i. pp. 176–270.
† Celsus de Medicinâ, lib. iii. chap. x.

employed by Celsus, giving as the cause an afflux of the blood. His four humors consisted of blood, serum, bile, and black bile. "The food," he says, "if badly digested, becomes corrupted, and the blood charged with these corrupted matters creates heat and swelling in parts in which it rots."* The Arabian school, with Avicenna as its ablest expounder, was governed altogether by Greek antecedents, and furnishes nothing new. Coming down to 1520, we learn from the writings of a representative man of that period, Ambrose Paré, that for thirteen hundred years not one step had been taken towards a more rational understanding of the process, and that on this subject the discoverer of the ligature knew no more than those who had preceded him. Richard Wiseman, who flourished and wrote extensively in the seventeenth century, only reiterated the doctrines of Galen. About 1675, a doctrine of which Van Helmont was the principal expounder taught that a sentient principle, "archæus," existing in the body, and which was offended by acidity, etc., sent the blood to a part to produce inflammation. Thomas Willis, an English physician, one of the first members of the Royal Society, and who was deemed worthy of burial in Westminster Abbey, attributed inflammation to obstruction in the vessels from the blood becoming too adhesive through an accumulation in it of sulphur.† Archibald Pitcairn, a Scotch physician, distinguished for his poetical and mathematical abilities, the preceptor also of Boerhaave, and whose writings occupy a conspicuous place between the years 1660 and 1723, makes all diseases to consist in changes in the quality or velocity of the blood. Inflammation he defines to be stagnation of the blood in the vessels of the part affected, and due to its viscid nature.‡

The discovery of the circulation could not fail to introduce more enlightened views upon a subject so palpably connected with the blood, and hence from Pitcairn's time its influence is seen in shaping the doctrines of medical writers. Boerhaave, in writing upon this subject, says, "the stagnation of the blood is caused in the smallest arteries by whatever makes the ends of the vessels, in their cones, and cylinders, so narrow that the diameter of their orifices is made less than the diameter of the blood-globules; the latter being pushed on by the remaining vital strength produce the effects of the present inflammation." De Gorter, another of the eminent men who gave reputation to the great school at Leyden, attributed the cause of inflammation to a greatly increased vital motion in the stimulated part.§ Stahl, the distinguished physician and chemist, the author of the doctrine of Phlogiston, made inflammation to consist in stasis of the blood.‖

Hoffman's definition of inflammation was, "stasis in the capillaries of a part into which the blood was driven by *spasm* of the arteries which prevented its equal circulation." This doctrine of spasm was destined afterwards to play an important rôle in the system of Cullen. The period between 1706 and 1766 was celebrated for the introduction of certain terms and the announcement of doctrines which, although improved by physiological experiment, have ever since formed a part of our medical and surgical language, and have only within a comparatively short period received their full interpretation. When a part is exposed to injury it attracts to itself an unusual amount of blood. This power was termed "*irritation*," or "*irritability*." It assumed a certain susceptibility or property in a tissue or organ to recognize impressions, and to respond to such when of a certain kind, as in inflammation, by determining an afflux of blood to the same; and thus we find Boissier de Sauvages demonstrating on a kitten's ear, in some respects, the same phenomena which Hunter exhibited in the rabbit's ear, Paget in the wing of the bat, and still later others in the mesentery of the frog,—namely,

* De Humoribus, ed. Huhn, vol. xvi. p. 131.
† Works, fol., Lond., 1684, Pharmaceutiæ Rationalis, part ii. p. 59.
‡ Physico-Mathematical Elements of Medicine.
§ De Gorter on Vital Motion, 1737.
‖ Systematic Medicine, Theoretic Part, sect. ii., Pathol., Halle, 1707, p. 246.

an increased vascularity upon the application of a stimulus. During this same period the influence of the nerves within the walls of the blood-vessels upon the circulation was clearly announced by Borden, and still more clearly by the Scotch physiologist Whytt, the successor of Sinclair in the University of Edinburgh, who affirmed that the action of the small vessels in inflammation was due to the influence of the nerves.*

Coming down to the last century, the student will find the subject of inflammation largely discussed in the writings of one of the most remarkable men that have ever adorned our profession. Not only was he a great medical philosopher, but he was also a marvel of patient industry. His entire life was comprised within a period of sixty-five years, in about thirty of which he not only built up a great museum and trained many eminent surgeons (among them Abernethy, Sir Astley Cooper, Sir Everard Home, and others), but also produced works which ruled English medical thought with almost unchallenged sway for nearly half a century after he was dead. Hunter did not regard inflammation as a disease, but as a salutary operation consequent upon violence or some disease.† Believing in a certain kind of union of divided parts, without inflammation, that which is now called "immediate union," he defined inflammation as that "action which is produced for the restoration of the most simple injury in sound parts, which goes beyond the power of repair by the first intention." He believed in the existence of a principle dwelling in the body,—in every part of the body,—an intelligent, vital power, which presided over inflammatory as well as other processes, the results of which were based upon their utility. In other words, Hunter believed in a principle, an entity, residing in, and united with, every part of the body, yet independent of it; an essence possessing intellectual and moral endowments, and which, standing like a sentinel on every watch-tower, always on the alert to detect every injurious or hurtful intrusion, called into action, for specific definite ends, those operations which we call morbid. In this particular his system rested upon a foundation not unlike that of Van Helmont, Stahl, and others. In reference to the capillaries, their fullness in inflammation was not regarded as being caused by relaxation, but by active distention. He was the enemy of the doctrine of humors. The blood he believed to be a living fluid, fibrin its most important element, and he esteemed its power of coagulation as akin to the property of contraction possessed by a muscle. He divorced inflammation and repair, and taught surgeons that suppuration was not necessary to the healing of wounds. He made seven varieties of inflammation,—adhesive, suppurative, ulcerative, gangrenous, œdematous, erysipelatous, and carbuncular.

We come now to a period when the microscope was introduced into medicine as a means of investigation, shortly before the year 1768. The tissues which, from their transparency, furnished the most satisfactory demonstration of the circulation in the minute vessels, were the foot and mesentery of the frog; and it was after witnessing the movements of the blood through the capillaries of the latter that Fabre‡ declared that obstruction in these could not be a necessary condition of inflammation, for when one vessel became blocked the blood immediately sought other channels; and he immediately arrived at the same conclusion with Borden and Whytt, that the nerves attract the blood towards the place in which they are stimulated. Dr. Wilson Phillip, from contemplating the same phenomena, concluded that debility of the capillaries was the initial step in inflammation, inducing retardation of the blood, which obstruction provoked increased action in the contiguous arteries. During the early years of the present century, certain terms were introduced, such as the "*pouring out*," in inflammation, of serum, fibrin, etc., by Mr. Dowler; or the "*effusion*" of liquor san-

* Whytt's Physiological Essays, 1755.
† Hunter's Treatise on Blood, Inflammation, etc., 1793.
‡ Fabre, Essays on Physiology, Pathology, etc., Paris, 1770.

guinis, by Dr. Babington;* and we may now say that two things had been generally conceded in the study of inflammation: 1. that the capillaries played an active part; and, 2, that the process was attended with an exudation. This exudation or pouring out, Mayo, in his "Outlines of Pathology," believed to be due to obstruction of the circulation in the inflamed part. This same author asserts with great earnestness that he clearly recognized in his microscopical observations the transformation of the blood-globules into pus, and thus anticipated what has been recently accepted as the doctrine of pyogenesis. Macartney† attributed to the sympathetic nerve, or to what he called the "organic consciousness" derived from that nerve, the first place in the production of inflammation, and concluded that the tonic dilatation of the capillaries was induced by the organic sense of injury or danger. He added to the local signs of inflammation "an alteration or suspension of the natural secretions of a part," and explained the redness as being caused by the minute capillaries which, when dilated, admitted red globules, but which in the normal condition contained only colorless serum. Macartney was an advocate of the doctrine of Hunter, that inflammation was not necessary for the repair of tissue. The dim shadowings of the vaso-motor system can be discerned in Macartney's teachings. About the year 1838, two German anatomists, Schwann and Schleiden, while pursuing their physiological studies, the former in the vegetable and the latter in the animal kingdom, discovered that the structures of both were alike made up of minute microscopic organisms or cells. These cells were supposed to arise from a homogeneous material,—*blastema*,—and by their various combinations and differentiation the different tissues were formed. It was upon this important announcement of the cell doctrine that Dr. Bennett constructed his theory of inflammation, regarding the process as one of modified nutrition, the contraction and dilatation of the capillaries being due, the first to spasm, the last to paralysis. The enlargement of the vessels allowed a larger amount of blood than natural to crowd into their channels, while the cell attraction of the tissues determined an exudation of the liquor sanguinis, the presence of which constituted inflammation. The theory of Bennett excluded both the vascular and the nervous system from actively, at least, participating in these results. In fact, the cell doctrine filled so largely the vision of physiologists and pathologists, that the blood-vessels were degraded to the position of mere conduits and carriers, the constructive and destructive builder being the cell, while in inflammation the exuded liquor sanguinis of an impure or vitiated quality interpenetrating the tissues constituted the pabulum for strange cell growths. Between the years 1841 and 1843, two very important discoveries were made by William Addison and Dr. Williams, both of England. Addison,‡ in speaking of the circulation in the frog's foot when inflamed, clearly recognized the distinction between the red and the white corpuscles,—the different positions which they occupied in the vessels,—the red moving along the centre and the white sticking to the circumference. He also asserted the identity of pus and the white corpuscles. Dr. Williams,§ in 1841, noticed the similarity between the corpuscular constituents of inflammatory exudations and the white corpuscles, and expressed the opinion that these passed through the walls of the vessels in the form of nuclei, and after their escape developed into pus- or lymph-corpuscles. He also observed an increase in the number of white corpuscles in the vessels of an inflamed part, and attributed the phenomena of inflammation to capillary obstruction, produced by viscidity of the blood from the presence of an unusual number of white corpuscles, and also to increased action of the capillaries. In 1842, Emmert,‖ in speaking of the action of the vessels in inflammation, recognized a primary contraction followed by dilatation, and asserted that between the walls

* Medico-Chirurgical Transactions, vol. xvi., 1831.
† Macartney on Inflammation, 1838.
‡ London Medical Gazette, December 18, 1840; January 11, 1841.
§ Practice of Medicine, 1848, 3d American edition.
‖ Beiträge zur Pathologie und Therapie, Heft i., Berne, 1842.

of the vessels and the corpuscles there existed an attraction, and that this attraction was antagonistic to a contracted condition of the vessels. In the same year Vogel* taught that in inflammation the irritant, be it what it might, acting through the nerves, induced a vital attraction between the blood and the tissues. In this way stagnation took place, the vessels dilating simply by the accumulation of blood. The exudation following was attributed to this same attraction.

Alison† believed that inflammation consisted in a local increase of a vital property of attraction among the particles of blood, and between them and the surrounding textures, and that the proximate cause of this process was to be sought as much in the influence of the solids upon the blood while passing through the vessels as in the blood itself. The chief reason assigned for such a view was the limitation of disease to a definite or circumscribed locality.

The pathological work of Rokitansky appeared between 1842 and 1846. This author makes *blood crasis* the central doctrine, asserting that all local diseases are determined by a primary blood constitution, which he terms a *crasis* or *dyscrasis*. According to this view, inflammation was the result of a fibrinous crasis, and exudation rather a mechanical process, due to an attenuation of the walls of the vessels from distention; and when transuded upon the surface of the membranes, such as the serous or mucous, it was in consequence of the least resistance being in that direction. He does not deny, however, that local disease may create a general or blood dyscrasia.

In 1846, Augustus Waller‡ witnessed, and was the first to describe, the passage of the white corpuscles through the walls of the vessel,—a very remarkable phenomenon, which, since 1863, has been still more satisfactorily demonstrated by Von Recklinghausen, Max Schultze, and Cohnheim, distinguished names belonging to the German school.

Wharton Jones, in 1851,§ in a paper on inflammation, after carefully considering the phenomena presented by the web of a frog's foot, arrived at the following conclusions:

1. That the contraction of the vessels and repulsion of the blood-corpuscles from one another and from the walls of the vessels, and the consequent acceleration of the circulation, are results due to nervous influence. 2. That dilatation of the vessels, and an attraction of the blood-corpuscles for one another and for the walls of the vessels, are caused by diminished nerve-influence. 3. That stasis or stagnation is the result of both combined. 4. That the exudation of serum which begins with the stasis is due to obstruction in the vessels, and that of plasma, from attenuation of the walls of these vessels from distention and pressure against their interior.

Thus far, it will be perceived, there has been a tendency to explain inflammation by searching for some single cause, or to make it consist in a certain condition. In 1853 the Lectures of Mr. Paget on surgical pathology were published. In these we find a broader and more philosophical treatment of the subject. He first endeavors to establish the conditions of healthy nutrition,—namely, 1, a regular and not far distant supply of blood; 2, a right state and constitution of the blood; 3, a certain influence of the nervous force; and, 4, a natural or healthy state of the part. In inflammation all these conditions are altered. Mr. Paget's experiments were made upon the wings of bats, which removed the objection so often made, that conclusions drawn from phenomena witnessed in cold-blooded animals were unsafe data upon which to construct a theory for similar processes in man. Various stimuli were applied, such as scratching with a needle, acetic acid, capsicum, and the pointed cautery, and the phenomena observed were sudden contraction and subsequent dilatation of the vessels, with diminished velocity in the blood-

* Wagner's Handwörterbuch den Physiologie, art. Entzündung, Göttingen, 1842, p. 317.
† Outlines of Pathology, etc., etc., 1844.
‡ Philosophical Magazine, vol. xxix., 1846, p. 397.
§ Guy's Hospital Reports, vol. vii., 1851.

current during the first, and a rapid flow during the last, of these changes. This dilatation, with increased rapidity in circulation in the damaged part, constitutes the active congestion or *determination* of authors. After a short period he noticed that the movement of the blood became slower, now ebbing and then flowing, until finally in some vessels it ceased entirely, so that at the centre or focus of the inflamed part there was *stagnation* more or less complete; around this, fullness with slowness of movement,—*congestion;* and still more externally, fullness with activity of movement,—*determination*. In addition, Mr. Paget noticed, what had been previously observed by Kölliker, a varicose condition of the capillaries (Fig. 19), and a pulsation in the veins, first discovered by Wharton Jones.

As to the causes which induce the blood-changes noticed in inflammation, he acknowledges that these have not been removed from the domain of theory, and therefore offers no speculation. The same statement is made in regard to the agency of the nerves,—that while there is abundant evidence, in the modified sensations of an inflamed part, that they are in some way concerned in the process, the exact relation which they bear to the disturbance is not, in the present state of our knowledge, demonstrable. Lastly, the changes in the part itself Mr. Paget makes to consist in the natural degeneration of structure, which is intensified by the altered conditions of nutrition, and its interpenetration of substance by the products of the inflammation. It will be seen from these remarks that this distinguished author regards inflammation as a destructive process,—one of decay; and that when any constructive force is manifested the resulting tissues are unstable and temporary.

Fig. 19.

Varicosities of the capillaries of an inflamed part.—From Paget.

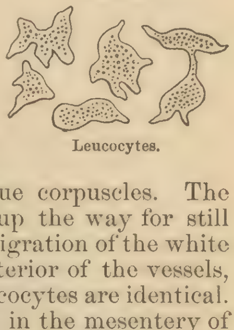
In 1858 was published the "Cellular Pathology" of Virchow, in which the idea of a living organism like the cell originating from a formless blastema, or what is sometimes termed free-cell development, was refuted, and the doctrine of every cell depending for its existence upon a pre-existing cell was placed upon a solid and rational foundation. With Virchow the active agency in inflammation was transferred from the blood-vessel to the cell of the connective tissue. It is the cell changed in its nutrition which attracts the contents of the vessels; the vessels are dilated by paralysis, nothing but serum can escape from them unless by rupture, and the cell forms are only the proliferation of the connective-tissue cells. The initial cause with Virchow was *irritation*, thus reviving an old term which has lately figured in the explanations given of this process.

In 1861, Lionel Beale, the distinguished microscopist, made public certain views which conflicted with the cell doctrine of Virchow, especially as to form, not as to function. These views were based upon the theory of protoplasm. That which corresponds to the cell is in the system of Beale termed a *mass of formative or germinal matter*, spherical particles extremely minute. This microscopic particle is a living substance, possessing the power of amœboid movements, or of sending out shoots or buds, and thus multiplying itself to a degree beyond computation. These masses of *germinal* matter are surrounded with what he calls *formed-material*,—really dead material,—formed by the germinal masses and elaborated from the blood. To illustrate: anatomists describe cartilage as consisting of a hyaline matrix, with cartilage-cells im-

bedded in its substance. According to Beale it should be formed-material, with imbedded masses of germinal matter. Beale's doctrine would class connective tissue as formed or dead material, incapable of performing any life-actions whatever, and therefore destructive to Virchow's favorite notion of the cell proliferation of this tissue. Inflammation, with Beale, is not the result of irritation, nor yet a chemical process, but an excessive supply of pabulum or blood, inducing active growth and multiplication of the germinal masses. When the capillaries are distended with blood, formative matter passes through the walls of the vessels and greatly multiplies in the extravascular spaces. The heat of inflammation he thought was the result of the rapid formation of germinal matter, and in his scheme the part performed by the nerves was secondary. Nucleated fibres are distributed to the capillaries and the intermediate tissue,—the first efferent, the last afferent. When a large amount of pabulum or blood is attracted to a part in which nerve-fibres of the latter class are distributed, the consequent swelling must compress these fibres, the stimulus of which, conducted to the vaso-motor centre, will induce, through efferent cords, capillary contraction, and in this way diminish the congestion or plethora by lessening the amount of pabulum or blood. If, however, the pressure from the attracted pabulum in a part continue for some time, the nerves may be paralyzed, and thus allow the vessels to dilate and to become surcharged with blood, constituting congestion. This was Beale's *self-regulating system.*

In 1863, Von Recklinghausen* directed his investigations to a process which Lieberkuhn as early as 1854, and afterwards Virchow, had noticed in a general way,—namely, the amœboid movements of white blood-corpuscles, or what are now generally called leucocytes. He found that their movements were of the same nature with those of amœbæ, and therefore that they were capable of moving from place to place. This locomotive power was shown by putting into the lymph-cavity of a frog the cornea of a rabbit, after injecting vermilion into the sac. On the occurrence of inflammation the cornea was found filled with leucocytes red with particles of vermilion, and similar in every detail to the pus-corpuscles in the lymph-cavity. The manner of movement is very curious. The little mass, perhaps at first spherical, sends out a filamentous process, sometimes several, one diminishing or receding as another elongates; the contents of the corpuscles run into the process, thus moving it,—the action reminding one of an insect using its antennæ and limbs. (Fig. 20.) The power of receiving into their substance foreign matters was also shown by injecting milk into the lymph-sac of a frog, and finding the leucocytes filled with milk-globules. When these bodies were observed upon inflamed surfaces, as on a serous membrane, Recklinghausen supposed they had originated by proliferation and migration of connective-tissue corpuscles. The remarkable contributions of this investigator opened up the way for still further progress, for in 1867 Cohnheim† announced the migration of the white corpuscles in inflammation from the interior to the exterior of the vessels, and that pus-corpuscles and white blood-corpuscles or leucocytes are identical. The phenomena of inflammation witnessed by Cohnheim in the mesentery of a frog which had been curarized were as follows: dilatation of the arteries, followed by that of the veins; at the commencement, acceleration, soon followed by retardation, of the blood-flow; accumulation of the white corpuscles in the peripheral part of the vessels, especially the veins, to which they adhered; while the red corpuscles moved through the central axes of the vessels. The accumulation of the white corpuscles in the veins kept pace with the slowing of the blood-movement; these corpuscles or leucocytes were seen gradually to pass, by virtue of their amœboid movement, through the walls of the

Fig. 20.



Leucocytes.

* Virchow's Archives, vol. xviii., 1863.

† Ibid., vol. xl.

vessels. Just in proportion as the little body disappeared from the inside, a corresponding button-like prominence was seen on the outside of the vessel, which gradually became pyriform, and finally maintained its hold only by a thread-like filament, which at last gave way, allowing the little sphere of protoplasm to launch forth into the perivascular space, and by its locomotive power to stalk about according to the forces by which it was controlled. This act was called the *migration* of a leucocyte. Passage through the walls of the vessels was effected also by the red corpuscles in the capillaries, forced through, however, he thought, by the blood-pressure, not by an amœboid action. Cohnheim, therefore, after experiments on the cornea, mesentery, and tongue of the frog, concluded that the pus-corpuscle was only a migrated leucocyte, and that the corpuscular elements of the perivascular tissues or fixed corpuscles formed no part of purulent accumulations. The essence, then, of the Cohnheim doctrine of inflammation was, the migration of the white blood-corpuscles or leucocytes.

In 1869, certain experiments were instituted by Prof. William F. Norris,* then at Vienna pursuing his studies, and Prof. Stricker, by which a further acquisition was made to our knowledge on this subject. Traumatic keratitis was induced in the cornea of a frog by the application of the nitrate of silver. The structure at the same time was excised, and examined both in the serum of the animal and after being subjected to the action of a solution of the chloride of gold. Changes were obvious in the fixed corpuscles of the cornea. They became enlarged and granular, their nuclei multiplied, and in less than twenty-four hours the characteristic movements of amœbæ were detected.

Stricker subsequently produced inflammation in the nictitating or conjunctival membrane of a frog's eye; and then, taking a cornea, cut it in two pieces, and transplanted each into this membrane, one piece immediately and therefore living, the other dead, its vitality having been destroyed in a bath of distilled water. After twenty-four hours both were examined: the first, or living piece, was filled with pus-corpuscles; the last, or dead piece, had very few. The conclusion drawn from these experiments of Norris and Stricker is the active participation of the tissue-corpuscles of an inflamed part in making up its cell-constituents, in opposition to the doctrine of Cohnheim that such come altogether from the vessels as wanderers. Stricker, regarding the capillaries as being composed of protoplasm, explained the passage of the corpuscles through their walls in inflammation by supposing these walls to be in an active molecular condition, opening for their passage and immediately closing on their escape. The same author has shown that in inflammation the walls of the capillaries very early undergo fatty change, and that as it progresses they become irregular on the surface, prolonged into processes, and these uniting with others form a reticulated frame-work not unlike connective tissue.

In 1870, observations were made by Ryneck with a view to solve the problem of the blood-stasis in inflammation. The thigh of a frog was surrounded with a ligature, the web placed within the field of his glass, and an irritant applied. The blood flowed with great rapidity to the focus of irritation. The ligature was next removed, and the stasis was seen to continue only at this point: therefore the circulation is not necessary to stasis. Milk was next substituted for the blood, and its globules behaved exactly after the manner of the blood-corpuscles under similar circumstances: therefore stasis is not due to the presence of the blood-corpuscles.

Again, certain metallic solutions, such as copper, were passed through the capillaries, by which their vitality was changed or destroyed. An irritant was then applied, but no stasis took place: from which it would appear that there exists some causal relation between the walls of the capillaries and the stagnation of the blood in inflammation. That viscidity, or excess of

* Versuche über Hornhautentzündung, von W. F. Norris und S. Stricker.

fibrin in the blood, is not the cause of stasis has been pretty clearly proved by Professor Lister.

When an irritant is applied to a part it causes (1) *acceleration of the blood-current*, with either dilatation or contraction of the vessels, according to the nature of the irritant; and (2) *stasis and transudation*, occurring simultaneously, and probably produced by changes in the vital properties of the walls of the vessels, an opinion set forth by both Ryneck and Stricker.

Leucocytes appropriate or absorb the tissues with which they are in contact. Such was the opinion of Aston Key and the Goodsir Brothers. The theory of this distinctive power of the leucocytes receives strength from the experiment of placing a piece of fresh cellular tissue beneath the skin. In a few days it is saturated with a liquid full of white corpuscles having full ingestive powers.

The conclusions of Burdon Sanderson upon the subject of inflammation are as follows:

"I. In every inflammation we have three classes of changes: 1. Effects of disorder of the vascular nerves and their centre, as witnessed in acceleration of the blood-stream with either dilatation or contraction of the vessels. 2. Effects due to change in the properties of the walls of the capillaries, manifested by stasis and exudation. 3. Effects of the stimulation of cells by the exudation of liquor sanguinis, as seen in the rapid growth and multiplication of cells resulting in the production of tissue or pus.

"II. Of these three orders of phenomena, the effects due to change in the properties of the walls of the capillaries can alone be considered as essential to the presence of inflammation, and which may therefore be considered as having its seat in and about the veins and capillaries, the earliest and most uniform effects of irritation or injury being witnessed in these localities.

"III. The nervous and vascular effects of local irritation cannot be strictly considered as successive stages of one process; for the determination of blood to the place of irritation—the result and purpose of the vaso-motor disturbance—does not bear any relation to the local vascular change, save in determining a more abundant exudation, but the vascular and tissue changes are to be considered as successive changes of one process.

"IV. The manner in which the living walls of the vessels are changed by injury so as to permit the passage of the blood is not determined; the same is true of the nature of this change; but from certain observations made in reference to the structural alteration of the capillaries in disease and in repair, the inference is that the change consists in the transition of the material from the formed to the plastic state.

"V. The effect of inflammation is to modify the action and properties of cells. Those which are stable, or form a part of permanent structures (as, for example, the connective-tissue corpuscles), enlarge and manifest amœboid movements, multiplying either by division or endogenous growth."

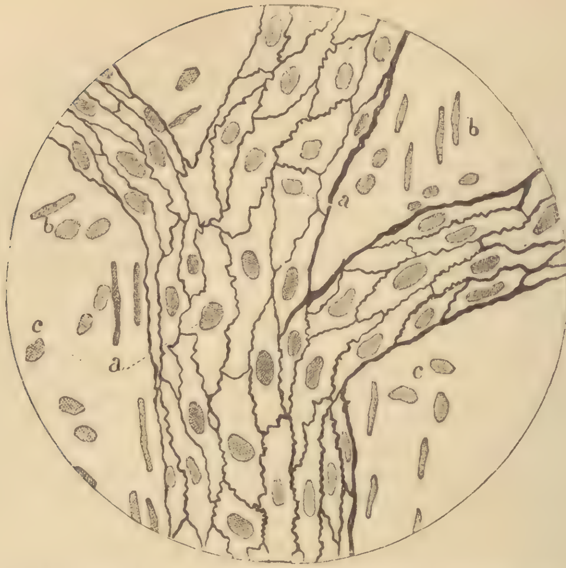
The manner in which the corpuscles make their way through the walls of the vessels, or effect migration, has been and is still a subject of controversy. Cohnheim believed in the existence of pores, or stomata; Stricker, in active molecular change in the walls of the vessels. In 1870, Colonel J. J. Woodward, Assistant Surgeon, U.S.A.,* in some very careful observations on the histology of the minute blood-vessels of the frog, prepared with stainings of the nitrate of silver, not only satisfied himself of the existence of pores, or stomata, but also by micro-photography secured capital pictures of the same (Figs. 21, 22, 23, and 24). These pores, or openings, are situated at the junction of the endothelial cells.

In 1873, Arnold,† of Heidelberg, experimenting on the tongues of frogs, also came to the conclusion that the passage of the corpuscles was effected

* Report to the Surgeon-General on Certain Points connected with the Histology of Minute Blood-Vessels.

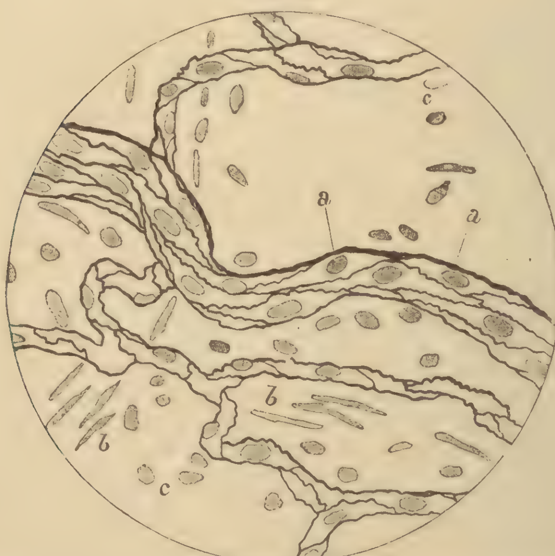
† Virchow's Archives, August, 1873.

FIG. 21.



From a vein in the urinary bladder of a frog, showing the vascular epithelia, with their nuclei, of a minute vein formed by three radicals. The dark zigzag lines are the boundaries of these cells stained with nitrate of silver.

FIG. 22.



From the urinary bladder of a frog, showing a minute artery with a few capillaries, and (*a*, *a*) the nuclei of the epithelial cells.

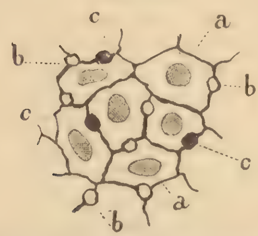
through openings, or pores. On the other hand, Professor Balogh, of Pesth,* and Dr. Feltz, of Strasbourg,† have not been able to discover such openings, and therefore do not admit their existence.

* Virchow's Archives, xlv. 19.
† Journal de l'Anatomie et de la Physiologie, January and February, 1870.

Fig. 23.

c, c, c, Stomata between epithelial cells of minute vein.

Fig. 24.



Vascular epithelia, with their nuclei, *a, a*; vascular stomata, viz., the clear orifices surrounded with dark lines *b, b*.

Nerve-Agency in Inflammation.—Enough is known to prove that the vascular system is not one of passive conduits or channels for blood-transportation. It is necessary to the well-being of the organs that the circulation should be equalized; that it should not be flood-tide at one place and ebb at another. No system of elastic tubes could execute the office of definite distribution. In certain pathological conditions the accumulation of blood in limited districts is another evidence of there being some influence at work by which a regulating power over the circulation through the vessels is maintained in health. The very arrangement of the structure of the vessels proves this. We find in their walls muscular fibres disposed circularly, and yellow elastic tissue; but muscular tissue would be useless without nerves; and, while much is yet to be learned in this direction, enough is known to render it highly probable that portions of the nervous system play an important rôle in the process of inflammation. Between the nerves and the parts to which they are distributed there are reciprocal influences or actions. Nothing is more familiar than the wide-spread tenderness which sometimes follows the local injury of a nerve, such as the prick of the finger with a pin, from which the entire hand, and even the arm, may become painful. If the cord of the sympathetic in the neck of a rabbit be divided above the inferior ganglion, after the method of Claude Bernard, the vessels of that side of the head, both within and without the cranium, become filled with blood, giving rise not only to increased redness, but also to increased temperature; dilatation, therefore, has followed the lesion. It is said that in such a case there are other influences at work to attract the blood in undue amount to the damaged region, such as the increased nutrition and secretion stimulated by the plethora, and the active chemical changes which follow the accompanying elevation of temperature. Still, it must be evident that the initial cause, whatever be the sequelæ, was the nerve-injury.

Magendie, after division of the fifth nerve,* found that inflammation followed in the conjunctiva, cornea, iris, and finally the entire eye. The investigations of Valentin were followed by similar results. Moritz Schiff† ascertained that to produce inflammatory and suppurative changes in the eye it was only necessary to divide the ophthalmic branch of this nerve; while the experiments of Meissner‡ would seem to indicate that the inflammatory change depends upon its inner fibres (perhaps trophic) alone, as no such result followed when these were left undivided. The agency of the fifth nerve over the circulation

* Journal de Physiologie expérimentelle, 1824.
† Untersuchungen zur Physiologie des Nervensystems, 1844.
‡ Henle und Pfeuffer, Zeitschrift (3), xxix. 96.

in the vessels of the eye has been also further corroborated by the late Von Graefe,* the celebrated German ophthalmologist.

Again, if the lingual nerve distributed to the submaxillary gland be subjected to irritation, as practiced by Ludwig, a profuse flow of saliva immediately begins. This was produced in the same manner as when tobacco or some other irritant is taken into the mouth,—that is, through the glosso-pharyngeal as afferent, and some other nerve as efferent: it is a reflex phenomenon. What that efferent nerve is will appear by the experiment of Schiff, in which the chorda tympani was divided, after which no amount of irritation of the mucous membrane of the mouth could excite the secretion. It would seem clear from this test that this little filament is a trophic nerve, and determines the blood to the gland; in other words, determines dilatation of the vessels. If now the cervical sympathetic be galvanized, as was done by Eckhard, the saliva lessens in quantity and is changed in density; the vessels diminish in size, the gland becomes pale, and the blood dark and venous in character. If the excitation be now applied to the lingual and chorda tympani nerves, red blood rushes into the gland, the vessels pulsate and become dilated, and secretion increases rapidly. The conclusions from such experiments are, that the sympathetic produces contraction, and the chorda tympani dilatation, of the vessels supplying the submaxillary glands.

Again, Loven† has shown that the vessels can be influenced in their size and the circulation in its movement by irritating certain sensory nerves. If the auricular nerve be divided and its central end irritated, dilatation of the vessels of the ear follows.

The experiments of Saviotti‡ and Riegel,§ which were undertaken with a view to determine whether the blood-vessel changes in inflammation were referable to direct or to reflex influence through the nerves, would appear to show that mixed nerves, like the sciatic, contain filaments from the sympathetic; that the latter, or ganglionic nerves, have a central origin,—the medulla oblongata; that irritation of certain sensory nerves does produce contraction of the vessels after a reflex manner, through the filaments borrowed from the ganglionic system. In fine, the existence of a vaso-motor system of nerves, the sympathetic, with a spinal centre, the medulla oblongata, whose peculiar office it is to regulate the lumen of the vessels and the force and rapidity of the circulation through their channels, may be accepted as a well-established fact. There is some diversity of opinion as to the character of these changes in the size of the vessels, whether active or passive. There is no dispute as to contraction. This is deemed to be an active change, produced by a motor force forwarded to the vessels through a certain set of nerves; but it is regarding the dilatation that opinions disagree. According to some, it is simply paralysis; with others, it is a passive act, or a return to an original condition; and, with another class, it is neither, but as much an active change as that of contraction, and produced by a special set of nerves. Moritz Schiff was a strong advocate of the latter view, and supported it by section of the vascular nerves of the ear of a rabbit. This was followed by an arrest of the regular movements of these vessels, and, after a time, a diminution or contraction of their walls. His inference from this was the following: "If the movements were the result of relaxation of the muscles around the vessels, division of their nerves should increase their dilatation; while just the reverse is the case."

Considering the subject from an anatomical stand-point, I cannot suppose for a moment that dilatation is an active process. There can be no anatomical explanation for such a view. The muscles being circular cannot actively dilate; the yellow elastic layer tends to keep the vessels open, as does also the blood. The muscular fibres antagonize these and strive to close them, and it is only when this opposing agency is removed by weakness or paralysis that their canals can enlarge.

* Archiv für Ophthalmologie, 1854.
† Ludwig's Arbeiten, 1867.
‡ Virchow's Archives, vol. l.
§ Stricker's Jahrbücher, Heft i.

In a subject of such importance, and where a large field is yet to be explored within the domain of neuro-pathology, hasty generalizations are unsafe, and it is the part of wisdom and sound philosophy to refrain from enunciating laws until we are in possession of a larger store of facts. There are many earnest, cautious, and well-trained laborers in the physiological laboratories and institutes of research, who, though they may be embarrassed and crippled by that morbid sentimentalism which can look with complacency on the destructive absurdities of female dress and dissipation and yet grow pale and horrified at the death of a frog, yet will, despite all these disadvantages and discouragements, eventually find out the secret and clear up all obscurities.

Terminations of Inflammation.—There can be only two terminations of inflammation,—*resolution* and *mortification.*

By resolution we mean the recession or disappearance of the phenomena of inflammation, leaving the tissues unharmed, or as they were before the attack. It is a triumph of the conservative force over the destructive operations of disease. This may take place in a few hours, or it may require days. The redness begins to fade, because the obstruction in the blood-channels of the inflamed district ceases, and the corpuscles move along without interruption; the vessels also begin to regain their natural size; the swelling diminishes, by the absorption of the transudation,—that is, by the serum as well as the wandering cells entering the vessels, either the veins or lymphatics or both, or by the cells undergoing fatty degeneration, in which state they can be readily taken up by the vessels; the pain subsides, the pressure and irritation being removed from the nerves; and the heat disappears, as all unusual textural change ceases. Such is resolution.

The possibility of inflammation ending in this manner makes it very desirable that we should always endeavor, during the inception and early stage of the disease, to bring about such a result. To this end we have two directly opposite plans of treatment,—cold and heat. The first should be used early, to stimulate contraction of the vessels, and thereby prevent exudation; the second, later, to impart sufficient warmth, and maintain, to some extent, the migrated cells in a mobile state, by which their dispersion is favored.

The second termination is mortification. Here the conservative force has been overmastered; the chemico-vital affinities which preserve textural form and insure structural function are so radically changed that the constituents of the part are disjoined and seek new combinations,—in other words, the part dies.

Metastasis.—This term has been used to express another termination of inflammation. It cannot, however, be properly so considered, but only as a sudden change of place in the inflammation. The most familiar example in illustration is the sudden translation of inflammation from the urethra to the epididymis, as sometimes takes place in gonorrhœa. The possibility of such a sudden transfer of attack from one organ or part to another is always a source of anxiety to the practitioner, particularly in gouty and rheumatic diseases, since the inflammation may at any moment be transferred from the foot or a joint to the stomach or the heart.

Treatment of Inflammation.—The treatment of inflammation may be considered under two heads, *local* and *constitutional;* and the indications are, first, to remove all causes which excite or maintain the disease; second, to secure resolution, or, if that be not possible, then to facilitate the removal of all inflammatory changes or results with the least possible damage to the inflamed part. With regard to the first, it is fortunately often within the power of the surgeon to put an end to the disease promptly. If a mischievous boy forces some body into his ear or nose and brings on an attack of inflammation, the cause is patent, and taking it away secures the subsidence of the disease; if a stone in the bladder excites a cystitis, its removal will be the

first step towards the arrest of the inflammation; if a splinter or ball enters the body, its extraction is the surest antiphlogistic. These causes are quite various: as, for example, occupation, as in the case of sand-paper manufacturers, in whom the air-passages suffer from exposure to siliceous dust; or an improper habit, as instanced in the pharyngitis caused by smoking. In whatever they may consist, their discovery and removal, if possible, constitute the first duty of the practitioner.

Local Treatment.—One of the most important local measures in the treatment of inflammation is *rest*. Motion tends to quicken the circulation in a part, and to favor textural change; the opposite—rest—removes a certain amount of stimulus from the vascular nerves, and tends to diminish functional activity. Thus, if a joint is inflamed, it must be placed at ease; if the student carries his studies far into the night until the head aches and the eyes become inflamed, he cannot expect to enjoy a clear mind and a strong eye until both have obtained respite,—the first by diminishing the hours of study, and the last by avoiding the stimulus of artificial light. To obtain the most thorough benefit from rest, it may be necessary to insist upon the quietude not only of the part inflamed, but also of the entire body. Every surgeon must have met with cases of local inflammation which obstinately refused to yield to treatment until general repose was enforced.

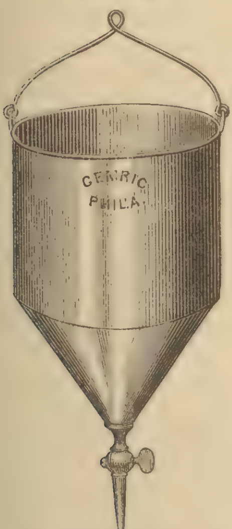
Position.—To derive the full benefit of rest, it will often be necessary to associate with it *position*. A part inflamed, where it is possible, should be *elevated*, in order to offer the resistance of gravity to the current of arterial blood, and the advantage of the same force to drain away that in the veins. Thus, when an extremity is the subject of inflammatory disease, it must be raised on an inclined plane. To secure the full advantages of position, muscular relaxation must not be overlooked: hence the necessity for moderately flexing a leg or an arm in cases of articular disease. It is not, of course, necessary to confine a patient to bed in every case of inflammation. A hand or arm so affected may be supported in a sling, and the patient walk about; but when the lower extremity is the seat of disease, articular or otherwise; when the body has experienced severe concussion; when the brain, lungs, intestines, or kidneys are threatened with inflammation,—the value of absolute repose is incalculable, both as a prophylactic and as a cure.

Cold.—This is a powerful agent; it lowers all vital activities. Its influence is seen alike in the vegetable and in the animal kingdom. In the former, the movement of the fluids is arrested and growth suspended. Many animals remain dormant during the winter months; no developmental force is displayed in the egg while kept at a low temperature; and in polar regions the inhabitants never attain the stature or mental vigor of races in the more temperate regions of the earth. When a low degree of cold is applied to a part of the body, it diminishes sensibility, and finally destroys it; it repels the blood and slows the circulation; it diminishes heat and transudation, and arrests the chemico-vital activity of the cells of the tissues, thus modifying the nutritive changes which are concerned in growth. Its influence, therefore, is realized by the nerves, blood-vessels, and protoplasmic masses of the part. It is, consequently, antagonistic to the conditions which favor inflammation and suppuration, and therefore is peculiarly valuable as a preventive. About the commencement of the present century, James Currie employed cold water to the surface of the body in typhus fever, and among the older military surgeons the remedy was extensively used. In the Crimean war, and that of our Rebellion, its value was well established. At Vienna, the local application of cold has been made to the abdomen in cases of peritonitis, it is alleged, with satisfactory results; and at St. Thomas's Hospital, London, it is a favorite remedy with Mr. Sidney Jones in the treatment of joint disease, as both a preventive and a controlling agent against inflammation. The temperature to be employed will vary from 50° to the freezing-point, the sensations of the patient having a proper weight in determining this. That which affords the greatest relief from suffering should be used, whether it accords with

our preconceived opinions or not. In its application, the person, clothing, and bed of the patient must be kept dry. Ice-water, either alone or medicated with various drugs, as laudanum, permanganate of potash, sulphate of zinc, acetate of lead, or vinegar, may be used.

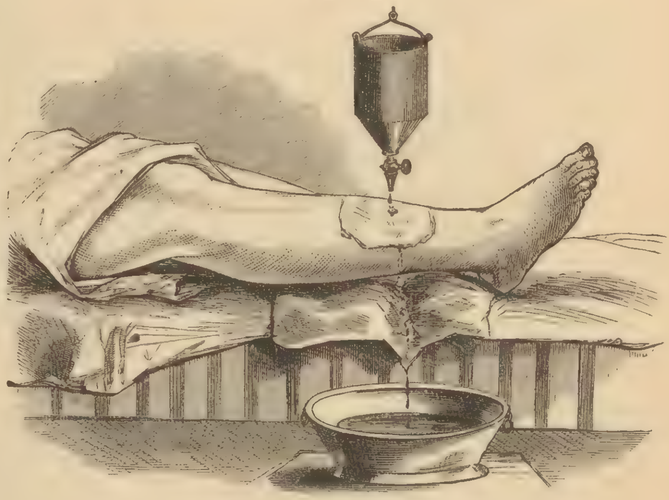
The simplest mode of using cold is, after adjusting the part, to apply over it pieces of old linen which have been saturated with water, renewing them as often as they become deprived of their moisture; or it may be most advantageously applied by irrigation, as recommended by McCartney, a method for which I have a great partiality. The mechanism by which this is accomplished is very simple. Either of two plans may be adopted, according to pleasure. Under the part to which the water is to be applied is placed a piece of rubber or oilcloth, fashioned into a gutter, and so inclined as to convey the redundant fluid into a vessel at the side of the bed. A basin containing the water is next placed on a table or stand higher than the bed; into this is dropped one end of an ordinary candle-wick, or a strip of linen, the other end being laid upon a piece of linen covering the inflamed surface. Soon

Fig. 25.



Tin irrigating vessel, with stop-cock to regulate the flow.

Fig. 26.



Irrigating a part by the suspended tin irrigator.

the fluid, by capillary attraction, will find its way along the threads of the wick and diffuse itself over the linen veil, running off, when this latter is surcharged, along the rubber placed below. A small gum tube may also be used as a siphon. A second plan is to take a strong bottle capable of holding a pint or a quart, knock off the bottom, and insert in the mouth a cork, through which a hole has been made to receive loosely a round plug of pine wood. Let the bottle be suspended over the bed, a short distance above the surface to be treated, the limb having the oilcloth adjusted as in the former method; then add the water, and loosen the plug in the cork just sufficiently to allow the water to escape in drops which shall fall upon the linen covering the diseased part. A more convenient vessel (Fig. 25) I have had constructed by Mr. Gemrig, which requires only regulation by a stopcock. The entire arrangement is exhibited in Fig. 26.

The power of this simple remedy, thus applied, in controlling destructive inflammatory action, especially in lacerated wounds of the hand and foot, is marvelous.

When it is desirable to apply ice, it may be broken into small pieces, and introduced into a bladder, or into gum ice-bags (Fig. 27), and laid upon or

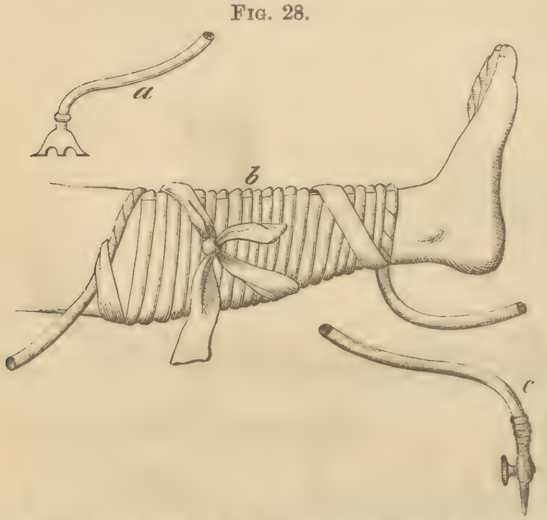
placed about the part to be treated; or it may be introduced into tin boxes, and these applied to the part,—a method which is in favor with Esmarch. In this way the cold is imparted without wetting the surface on which it rests. In all cases, whether wet or dry cold is used, a piece of flannel or linen should be interposed between it and the skin. Where the skin is unbroken, or in joint-inflammation, dry cold answers every purpose; but in the case of lacerated wounds, such as we often meet with in the hand and foot, inflicted by fire-arms, machinery, or railroad-cars, it is inferior to the moist plan, the latter not only serving as an antiphlogistic, but likewise washing away the products of inflammation and decomposition, by which the risk of blood-contamination is greatly lessened.

Fig. 27.

Ice-bag.

Another method of applying cold is that of Petitgand, which consists in filling with water a piece of rubber tubing several feet in length and of very thin walls, and, after securing the extremities so as to prevent the escape of the water until the adjustment of the tubing, coiling it about the inflamed part (Fig. 28) and making it fast by the turns of a roller. Thus secured, one end, *a*, is introduced into a vessel of water placed at a higher level than the patient, and the other, *c*, into a bucket so situated as to receive the waste.

Fig. 28.



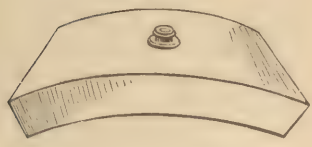
Petitgand irrigating tube: *a*, bell-mouth extremity of the tube; *b*, tube coiled around the limb; *c*, end fitted with regulating screw.

It is in the commencement and early stages of inflammation that benefit is to be derived from cold; but there are certain cautions to be observed in its use. If the part to be treated is damaged to so great a degree as to render its recovery somewhat doubtful; if repair has commenced but progresses feebly and slowly; if the patient complains of chilliness; or if there exists partial or complete paralysis,—then must the utmost caution be exercised in its use, or we may so lower nervous and vascular action as to destroy what little reactive force still lingers in a part.

Heat, with or without *moisture*, will, particularly in the later periods of inflammation, prove a valuable resource. Warmth is a derivative; it attracts the blood to the surface, quickens chemical change, is a stimulus to the locomotive endowments of the migrated corpuscles. A bag filled with hot sand, hot ashes, hot salt, or steamed bran, when placed about the chest in pneumonia or pleurisy, is most effective in relieving engorgement or congestion; a tin pan filled with hot water (Fig. 29), or a rubber bag (Fig. 30), fulfills the most valuable purpose in alleviating the pain of inflammation or neuralgia. When associated with moisture it mollifies the tissues, softening them so that they yield before effusions and take off pressure from the nerves. When it is desirable to employ moist heat, it may be done by saturating a piece of patent lint or linen with warm water, placing it over the part, and, to prevent evaporation, covering it with oiled silk, rubber cloth, or waxed paper. Spongiopiline can be substituted, or, what is much cheaper and equally efficacious, the paper poultice mass,—thick, soft, felted paper, having on one surface a

film of rubber.* In cases requiring a local anodyne, such a dressing may be made very soothing by the addition of a little laudanum to the water. Should the case be one of an open wound, or an ulcer with offensive discharges, two or three teaspoonfuls of chloralum, bromo-chloralum, or, better

Fig. 29.



Concave hot-water can.

Fig. 30.

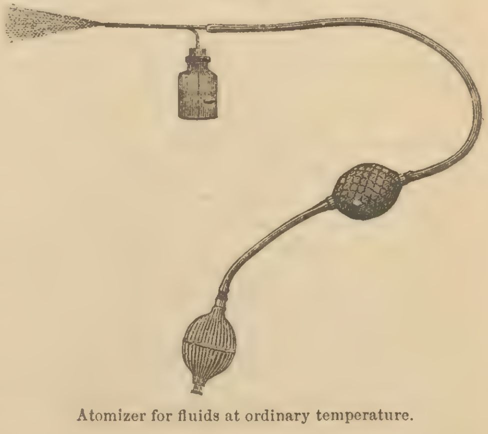
Gum hot-water bag.

still, a solution of permanganate of potash, or of salicylic or carbolic acid, may be added to the water with the effect of deodorizing all such discharges.

Fomentations.—In internal inflammations, either articular or abdominal, fomentations will sometimes be found beneficial. Several folds of thick woolen flannel wrung out of boiling water, laid over the inflamed region and covered with oiled silk, constitute the most eligible mode of using a fomentation. Various decoctions may be so applied with great benefit, especially in concussions of the abdominal and thoracic viscera,—the most common ones being made by pouring boiling water over hops or chamomile,—the latter seeming peculiarly comforting to the sensations of the patient. To derive the greatest benefit from such dressings, they should be renewed as often as they lose their heat.

Steaming.—The vapor from hot water, when directed upon a part tense and swollen, constitutes another agent of value. In cases of earache, stiff rheumatic joints, or catarrhal attacks either of the nasal or bronchial mucous membranes without exudation, much good will be realized from its use. The manner of using steam is very simple. Every housekeeper understands it. Pour some boiling water into a tin cup and invert over it a funnel, through the neck of which will issue the steam; or one end of a rubber tube may be slipped over the spout of a boiling teakettle, and the other applied to the ear, mouth, nose, or whatever part may demand its use. If we desire to apply it to a joint or limb, the part must be surrounded with either a blanket or piece of gum or oiled silk. The fluid thus converted into steam is often medicated by the addition of vinegar or hops, useful in tonsillitis and pharyngitis; or quicklime, in croup; tincture of opium, in irritating coughs; powdered cubebs, in chronic bronchitis, etc.

Fig. 31.



Atomizer for fluids at ordinary temperature.

Moisture is occasionally employed in the form of a spray, atomized, either

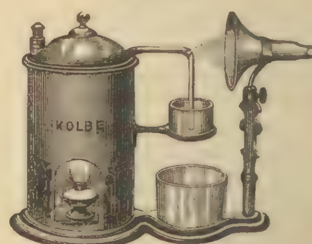
* This paper dressing was first used by Dr. Studdiford, of Lambertville, New Jersey, since which time I have suggested several improvements, which make it a cheap and valuable surgical dressing.

cold or warm, and is especially beneficial in inflammatory states of the pharynx and larynx. (Fig. 31.) The fluid used in this way is often charged with such agents as alum, nitrate of silver, tincture of iodine, tannic acid, and various other remedies. To create the spray it is only necessary to compress and relax alternately the lower ball attached to the hose of the instrument. The atomization is frequently effected by means of steam. There are two patterns of the steam atomizer, either of which answers an admirable purpose, the Boston (Fig. 32) and the Philadelphia steam atomizer (Fig. 33). Each consists of a boiler for the water, A, with a spirit-lamp beneath to supply the heat, two tubes with capillary canals, B,—one communicating with the boiler, through which issues the steam, the other with a cup containing the liquid to be atomized, F, and their free extremities nearly at right angles with each other, while in front is a funnel-mouthed glass tube, D, secured by a rubber band to the top of an upright to receive the spray and conduct it to the mouth of the patient, who receives the other end between the lips.

Fig. 32.

Boston steam atomizer.

Fig. 33.



Philadelphia steam atomizer.

Heat and moisture are also employed in the form of poultices,—applications of great value, especially when the object is to favor suppuration, for which purpose nothing else can answer so well. The materials in common use for poultices are stale bread crumbled into small pieces and reduced to a pulp by stirring it well with boiling water; flaxseed meal—the finer the better to retain heat—brought to the consistence of a soft paste by the same means; powdered slippery elm introduced into a bag and dipped into hot water before applying; corn-meal stirred in water and kept boiling until it assumes the consistence of thick mush. When once reduced to a soft homogeneous mass, the material should be spread smooth and evenly over a piece of muslin, and covered with some fine fabric like tarlatan. Sometimes we shall realize much more benefit by not interposing anything between the poultice and the surface. These, when applied, should be covered with waxed paper or oiled silk, that the heat and moisture may be retained. Such poultices may be medicated in various ways. If it is desired to assuage pain, laudanum, opium, or morphia may be added; if to constringe the vessels, acetate of lead or Goulard's extract; if to deodorize, yeast, porter, charcoal, carbolated oil, or Labarraque's solution. They should be changed once in six hours, and never be made too heavy.

Local Blood-Letting.—In the early stage of inflammation we possess no means more influential in arresting the progress of the disease. It operates directly by unloading the over-distended vessels. Blood may be drawn in different ways:

1. *By scarification*,—with the point of a delicate thumb-lancet. The instrument should be carried back and forth over the inflamed surface with a rapid and light hand. This method is occasionally used in a turgid state of the vessels of the conjunctiva.

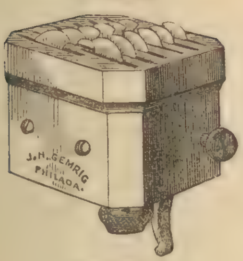
2. *By incisions.*—These should be made with an ordinary bistoury or scalpel, and their depth and length must be determined by the urgency of the case. In phlegmonous erysipelas, urinary infiltration of the perineum and scrotum, paronychia, and ischio-rectal abscess, they should be both deep and free, extending down to the deep fascia, and below it, if the inflammatory products are so situated. When early practiced in the above diseases, the beneficial effects are both immediate and permanent; not only are the vessels relieved from distention, but the nerves also from pressure, by giving exit to the pent-up blood, serum, and lymph. To neglect so imperative an indication is to trifle with the welfare of structure and the life of the patient. Care must be observed that no vessels of any magnitude are damaged.

3. *By scarification and cups.*—There are two plans of cupping,—the *dry* and the *wet*. In the first no incisions are made, only the cup being applied to the surface and exhausted, by which both counter-irritation and depletion are effected. The discoloration of the parts shows that considerable blood has been drawn through the vessels into the cellular tissue. In the second method, numerous slight incisions are made at the same moment by a scarificator (Fig. 34), and the cup, applied directly over these, draws away the

Fig. 35.

Fig. 36.

Fig. 34.



Scarificator.

Exhausting by the pump.

Exhausting by the gum ball.

blood by suction. Cups should not be applied directly over the inflamed surface, in consequence of the pain which would be experienced. The air in the cups may be exhausted by taking little slips of paper, either dry or moistened with alcohol, and, after igniting them, throwing them into the glasses a moment before they are turned down upon the surface; or it may be removed by an atmospheric pump after the cup is in position (Fig. 35); or by the attachment of a gum ball (Fig. 36). In inflammations of the thoracic viscera, or of the contents of the cranium and the spinal canal, great relief may be expected from their use, especially when general bleeding is inadmissible. As the scarifications leave cicatrices which are never erased, wet cups should not be applied upon exposed parts of the body.

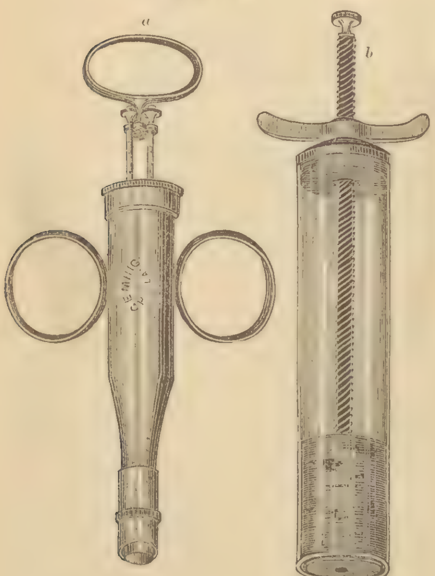
4. *Leeches.*—These, when accessible, enable us to take blood from localities where cups cannot be applied, as about joints, at the verge of the anus, the cervix uteri, etc. They should not be applied directly over the inflamed part, but contiguous to it; nor should they be allowed to attach themselves to parts which are very loose in their texture from abundance of underlying connective tissue, such as the scrotum or eyelids, otherwise extensive ecchymosis will follow. When they are used for an inflamed eye, or in orchitis, they should be placed near the internal canthus, where there is a free in-

osculation of vessels, or over the spermatic cord. The bleeding may be encouraged after the leech drops off, by warm fomentations. Occasionally the hemorrhage proves troublesome, and requires attention. The measures best suited to such cases are the following: sprinkle a little of the salt of the persulphate of iron or alum over a piece of linen, and place it upon the bleeding point, retaining it with a compress; or saturate a dossil of lint with Monsel's solution of iron, and with it cover the bite; or touch with the fine point of a crayon of nitrate of silver. Should these fail, apply the point of a knitting-needle heated to redness; and lastly, if it becomes necessary, pass a fine pin below the wound and cast about it a thread (Fig. 37), which cannot fail to arrest the bleeding. An artificial leech is frequently used for the abstraction of blood, particularly in inflammatory affections of the eyes. A rod forced down gives a rotatory motion to an elliptical-shaped knife, which cuts a small valvular flap, like that made by the leech, from which the blood is sucked by a long tubular cup containing a piston (Fig. 38). In Fig. 39 the lancet is made to cut by a rapid revolution with a cord, or by forcing down a stylet.

FIG. 37.

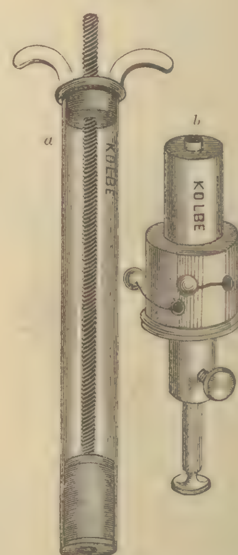
Mode of ligating a leech-bite.

FIG. 38.



Artificial leech: *a*, the lancet; *b*, the suction-tube.

FIG. 39.



a, Suction-tube.
b, Lancet propelled by a cord.

Diminishing or cutting off the supply of blood.—This is an American plan. Dr. Onderdonk, of New York, originated and executed it in a case in 1813. During the late war, Professor Campbell,* now of Georgia, noticed in cases where he was compelled to ligate the principal artery of a limb to arrest secondary hemorrhage that the most marked improvement took place in the wound. In Professor Campbell's cases the operation became a necessity in consequence of hemorrhage.

Mr. Maunder, surgeon to the London Hospital, has practiced the operation in several cases of acute traumatic suppurative inflammation, and from a limited experience deduces the following conclusions:†

* Southern Journal of the Medical Sciences; also Transactions of the International Medical Congress, September, 1876.
† London Lancet, July 10, 1875.

"1. That ligature of the superficial femoral artery has arrested acute inflammation of the knee-joint consequent upon a wound.

"2. That ligature of a main artery will quickly diminish profuse suppuration and prevent death by exhaustion.

"3. That, while it arrests profuse suppuration, it will, by allowing the patient to gain strength, afford an opportunity for amputation at a future time.

"4. That gangrene and secondary hemorrhage, as the result of ligature, should not be anticipated in a healthy subject. That our dread of these has arisen from our knowledge of the consequences of the ligature in instances of known diseased vessels,—aneurism, for example.

"5. That symptoms of inflamed bone, 'starting pains,' quickly disappeared when the femoral had been tied.

"6. That arterial tension of the rest of the body will be increased beneficially by the ligature."

I have so little apprehension of failure of the circulation after ligature of main arteries in healthy subjects, that I do not hesitate to recommend this operation in injuries of large joints, such as the knee, elbow, and wrist, and where suppurative inflammation, unless quickly controlled, will result in the loss of the limb or life of the patient.

Digital compression.—Diminishing the supply of blood to an inflamed part by digital compression, a suggestion of Professor Vanzetti, of Padua, has been tested in Prague, Paris, and, to a limited extent, by Mr. Moore, of the Middlesex Hospital, London, with encouraging results. Neudörfer speaks in extravagant terms of its value, after trying the plan in over one hundred cases.

Counter-irritants.—There is no small diversity of opinion as to the value of this class of remedies. In many cases of inflammation of internal organs I am favorable to their employment as adjuvants to other remedies. They should be used so as to produce simply a rubefacient or reddening effect; when carried beyond this they prove prejudicial.

They act by establishing artificially an attractive point for the blood, and thus diminish both the force and the quantity of that fluid in all contiguous parts. An inflamed tissue is like a beleaguered garrison: its enemy, the blood-current, pours in upon it from all sides; the physician comes to the rescue, and, like a sagacious general, attempts to draw off the enemy or divide its forces by sending a detachment to threaten another post. Counter-irritants form these detachments. They should, therefore, be applied not so near as to add to the already overcharged vessels of the inflamed part, nor yet so far distant that their operation will not be felt by these vessels. Their value is greatest when the acute stage is beginning to wane.

Of this class of remedies we may notice *mustard-plasters;* they are prepared by taking the flour of mustard, or, if that is not at hand, the bruised seed of the sinapis nigra, or black mustard, and mixing it with just sufficient wheaten meal and water to make a paste, which should be spread smoothly upon muslin or brown paper, and covered with a piece of tarlatan or very fine linen, so that the agent shall not come immediately in contact with the skin. In a few minutes its rubefacient effect will be produced, and the patient will complain, first, of a sense of warmth, and then of burning, which last, after a little time, begins to subside, when the plaster should be removed. Usually from ten to fifteen minutes will suffice to procure the requisite action. It should never be allowed to vesicate, as the part would then become exceedingly painful, and would sometimes be difficult to heal. Such a plaster, worn for the proper period over the chest, abdomen, or back, in cases of fugitive pains, congestion of the lungs, of the intestines, or of the spinal marrow or its meninges, is often followed by the most striking alleviation of suffering. Other articles of this nature, such as the linimentum saponis, turpentine and olive oil, and chloroform liniment, may be employed with advantage for similar conditions.

Vesicants.—These are not only counter-irritants, but also depletives; they produce a large flow of serum, and so unload the vessels. The articles for such purpose in common use are the ceratum cantharidis, cantharidal collodion, acetum cantharidis, and cantharidine tissue. They should be removed after four or five hours, and the part covered with a warm poultice, which will raise the vesicles and save considerable suffering. The absorption of the cantharidin sometimes produces a troublesome irritation at the neck of the bladder,—strangury. This may be often prevented by incorporating a little camphor with the cerate, or by covering the blister with tissue-paper saturated with dilute acetic acid. Its early removal, however, is the surest method of preventing such an effect. The use of a laudanum injection, and drinking freely of some diluent, as barley-water, or slippery elm or flaxseed tea slightly acidulated with lemon-juice, will soon relieve such symptoms should they arise. As a rule, blisters should not be applied to the very young, to the aged, or to persons debilitated by previous disease. In such they are liable to produce great constitutional irritability and occasionally sloughing. They come in with the best advantage after the storm of inflammatory violence is over, when the disease has been measurably broken, but not defeated. Blisters may be produced in a very short time by placing upon the surface a piece of lint saturated with either aqua ammoniæ or chloroform, and covering it with oiled silk; vesication will speedily follow. The value of these substances as vesicants, however, is much inferior to that of cantharides. The after-management of a blister plaster consists in its careful removal, so as not to strip off the cuticle, making minute punctures with the point of a lancet or needle at the base of each bleb to drain away the serum, and afterwards dressing with simple cerate, a light flaxseed-poultice, or, if it is desirable to keep the surface discharging, with compound resin or savine ointment. Occasionally the blistered surface becomes intensely red and painful, with here and there a small suppurating ulcer, producing great nervous disturbance of the patient. Emollient poultices will contribute to allay these symptoms; also the benzoated oxide of zinc ointment, and best of all, in my experience, a linen rag well scorched with a hot smoothing-iron, thinly covered with simple cerate, and then well dusted with prepared chalk. This dressing laid over blisters will generally give marked relief, and induce rapid healing.

Counter-irritation may be carried to a still greater degree of intensity by producing suppuration, for which purpose we have setons, issues, moxas, and the hot iron. These old heroic remedies have gone much out of fashion. Now and then some one fond of lingering about the mausoleums of ancient medicine and bringing to light their rude weapons of torture attempts to revive and popularize their use; but I do not think I misrepresent professional sentiment in America by saying, save in exceptional cases of a chronic nature, let them rest in peace.

Iodine, while it acts as a counter-irritant, produces undoubtedly another effect, which we are wont to term alterative; and the same may be said of the nitrate of silver, which has been extolled by Higgenbottom, of England, as a local application in inflammation, and which, if the solid stick is used, will often arrest and resolve it. In solutions of eight or ten grains to the ounce of distilled water its value in pharyngitis is well known; and so also is that of weak solutions in cases of gonorrhœa and conjunctivitis. Iodine is most efficacious in chronic inflammations attended with transudations, organized and unorganized. If early used it is often capable of aborting inflammation. As it is ordinarily applied its efficacy is doubtful. It should be brushed over the seat of the diseased part as long as the tissues will receive it, and it is astonishing how much can be introduced into the skin. Iodine, when it begins to produce irritation and burning, should be discontinued for a time until these subside, as the suffering is often intolerable. The peculiar action of the drug may be secured without any of its unpleasant effects, by associating it with other substances, as in the following formula:

℞ Liquoris Iodinii Compositi, f℥vi;
Pulveris Sacchari Albi,
Pulveris Acaciæ, āā gr. xl;
Aquæ Destillatæ, f℥ii.
M.

Compression constitutes a valuable remedial measure in inflammation. It can be applied either by the roller, adhesive straps, or elastic bands. If the roller is applied with an evenly-distributed pressure, it is of great importance; but if done without reference to this, it is capable of much damage. Pressure acts in several ways: it secures muscular quietude; supports the vessels and opposes transudation, by resisting over-distention of their walls; and quickens the absorption of the serum and lymph, reducing, in this manner, the thickening of the tissues. In old, indolent ulcers, the conjoined pressure of adhesive straps and roller works marvels in removing structural alterations and helping forward the work of repair. Though useful in all stages of inflammation, it is peculiarly so in the chronic form of the disease. When applied in acute cases, some care is necessary that the bandage shall not become too tight in consequence of swelling.

Antiseptics.—Since the publication of Professor Lister's papers on carbolic acid dressings, much interest has been attracted to the subject of antiseptics in inflammation; but, as these remedies are best suited to wounds, I shall not at this place enter upon their consideration.

Constitutional Treatment.—*Blood-letting.*—This is a potent remedy, and must be used with the greatest judgment. Though unquestionably greatly abused by practitioners, from Botalli down to 1836, when Mackilwain* and Robert Williams† raised their warning voices against its indiscriminate use, yet there is reason to believe that physicians and surgeons of the present day sometimes err in the other extreme, intimidated by popular clamor, and so lose vantage-ground in dealing with certain grave inflammatory diseases. I do not propose to enter upon a defense of the remedy; but when I see a headache disappear, as if by magic, after a slight bleeding of the nose; a lung, in pneumonia, relieving itself by a bloody expectoration; an erysipelas affecting a stump after amputation, resisting every remedy, but vanishing in a night after a slight secondary hemorrhage,—I do not hesitate to say that I still find it necessary occasionally to employ the lancet.

The general abstraction of blood acts in several different ways as an antiphlogistic. It is derivative, as the current tends to the point of escape; it removes out of the body a certain amount of infected stimulating fluid; it diminishes the temperature, and lowers the sensibility of those central masses of the nervous system which govern the walls of the blood-vessels. This last effect is very striking in the anæsthesia which follows large hemorrhages. I venture, therefore, to say that in the *invasive stage* of inflammation of the pleura, lungs, peritoneum, brain or its membranes, in a person of a strong, vigorous constitution, it is a remedy of incalculable value and stands without a rival among our therapeutic resources. Thus employed, it either cuts short the morbid process at once or renders it an easy conquest by other means. It would not be proper to employ general bleeding in strumous constitutions, in persons of a feeble organization, or even in strong, vigorous individuals when the prevailing type of disease is of an asthenic kind. The citizens of a great metropolis, like Philadelphia, are less able to tolerate the loss of blood than the sturdy inhabitants of the country. Children and aged persons bear its loss badly. The practice of drawing blood by proxy is a great error. No medical man, however wise or experienced, can say, without personally witnessing the operation, what amount of blood a patient shall lose. The pulse must settle that question; effects, not ounces, must be considered. The best position for the patient during bleeding is the semi-recumbent. If sitting, fainting may be produced before a sufficient quantity has been drawn to make any impression upon the disease. The

* Medicine and Surgery, 1838.

† Elements of Medicine, by R. Williams.

diminished force of the pulse, the artery becoming more compressible, and the sensations of relief experienced by the patient, are to determine the amount to be abstracted. When, from some idiosyncrasy, improper position, or excessive loss of blood, a patient becomes pale, sick at the stomach, with indistinct vision, and a perspiration breaking out over the face, indicating the approach of syncope, the recumbent posture, with the head low, should be adopted. If these symptoms do not pass away in a few minutes, certain restoratives should be employed as exciters of respiration, such as dashing cold water upon the face or applying the vapor of ammonia to the nose. Fainting is to be avoided when blood is drawn for the relief of inflammation, as the subsequent reaction would be so violent as to render void the benefits derived from the operation.

Depressants.—These are remedies which weaken the power of the heart's action, diminishing both the force and the frequency of its stroke. Aconite belongs to this class. Fleming's tincture of the root is a very active preparation, and, when given in doses of three, four, or five drops at intervals of two or three hours, will, after the exhibition of a few doses, reduce the number of the heart's pulsations very markedly. Veratrum viride exercises a similar power over the circulation. The preparation generally employed is Norwood's tincture, which may be administered in doses of three or four drops every hour or two until its constitutional action is produced. It is no unusual occurrence to find the pulse reduced in a few hours from one hundred and twenty to sixty or seventy beats in the minute. When these agents are administered, the patient should be seen frequently by the medical attendant, or the nurse should be sufficiently intelligent to recognize changes in the pulse. If these precautions are not observed, a dangerous depression may be induced, from which the patient may never rally. These remedies come in most happily after venesection, holding the circulation in abeyance after it has been reduced by the latter, or as a substitute for the lancet in cases where the urgency is not great. When the heart has been unduly enfeebled by their use, alcoholic stimulants are indicated until the danger is past.

Antimony exercises a power upon the heart and arteries not unlike that of aconite and veratrum. When given to the extent of producing nausea, the power of the heart is diminished, the pulse becoming feeble and frequent. If pressed to emesis, the change in the circulation is quite remarkable: the arteries become fuller and the blood-current slower, attended with an active state of the glandular apparatus of the skin, and sometimes looseness of the bowels. Tartar emetic in substance and antimonial wine are the two forms of this drug most commonly used. When the former is administered, it should be in minute doses, not exceeding one-thirtieth of a grain, in solution, and repeated at intervals of one or two hours, suspending its use or prolonging the periods between its exhibition whenever the patient complains of nausea. I have frequently given it as in the following formula during the traumatic or surgical fever of vigorous patients:

℞ Antimonii et Potassæ Tartratis, gr. i;
Liquoris Potassæ Citratis, f℥vi;
Liquoris Morphiæ Sulphatis, f℥vi.
M.—Sig. Dessertspoonful every two hours.

Except as directed above, antimony is no favorite with me, and is seldom necessary in surgical practice. In all cases where there is gastro-intestinal irritation it is contra-indicated, and in feeble constitutions, in the very young, and in the aged, its administration is improper.

Diaphoretics and diuretics.—The skin may be said to be an enormous gland. Through the countless emunctories which open upon its surface there is constantly eliminated, by sensible and insensible perspiration, an amount of solid and liquid materials equal to at least sixteen ounces daily; and its aid should be invoked in inflammatory disturbances of the system. Diaphoretics and

diuretics are depletive in their action, and hence reduce temperature. They remove the products of textural change, and thus render the blood less irritating to the nerve-centres. Of the greatest importance is the action of the kidneys; the skin may supplement their function, but can never supersede it. Every surgeon knows well their importance to the success of an operation. Through these channels are removed urea, chlorides, phosphates, and sulphates.

The articles best suited to depurate through the skin and kidneys are the liquor ammoniæ acetatis,—popularized by Raimond Minderer, physician to the Fugger family, at Augsburg,—the liquor potassæ citratis, the spiritus ætheris nitrosi, and the nitrate of potash. The first two may be given in dessert- or tablespoonful doses, the sweet spirit of nitre to the amount of one dessertspoonful, and the nitrate of potash in quantities of five to ten grains at intervals of two or three hours. For the proper action of either diuretics or diaphoretics an abundant supply of water, charged with carbonic acid, plain or acidulated with lemon-juice, is necessary. By its use the solids of the urine are greatly increased, as shown by the experiments of Böcker, through the chemical activities which are stimulated by its presence, while to the parched mouth, dry skin, and burning thirst of the patient the relief is incalculable.

In this connection may be noticed the use of water for sponging the surface of the body, by which its heat from the increased aeration of the blood and slowing of the circulation is diminished. Of the use of baths, or the various *packings* employed by those who conduct *water-cures*, I shall say nothing; for, whatever may be their value in certain forms of rheumatism or cutaneous diseases, they are certainly unsuited to most surgical cases.

Cathartics.—Like the skin and the kidneys, the mucous membrane of the intestinal canal forms an extensive emunctory. When brought into activity the effects are derivative, depletive, and refrigerant. There are few cases of disease in which it is not deemed necessary to exhibit a cathartic more or less active. The object in view will determine the particular member of this class to be used. Sometimes it is desirable to remove only the intestinal contents, which, by their accumulation, may act as a source of irritation; and for this purpose a Seidlitz powder, castor oil, or a compound rhubarb pill will be sufficient. Sometimes it is necessary not only to unload the bowels, thus getting rid of various secretions and other effete matter, but also to quicken or stimulate the action of the different glandular organs directly or indirectly connected with the intestine. For this purpose we have the sulphate of magnesia, or, what is better, the sulphate of soda, magnesia, or its citrate, bitartrate of potash, calomel, and the compound cathartic pill. The more drastic cathartics, such as elaterium, jalap, and croton oil, are much less employed than in former years. The salines mentioned produce watery discharges, thus unloading the blood-vessels, diminishing vascular fullness, reducing the temperature of the body, and inviting the flow of blood towards the intestinal mucous membrane. When the pressure is in this way removed from the interior of the vessels their capacity for receiving inflammatory products, especially of a liquid nature, is greatly increased; and hence their value in dropsical accumulations. For this reason cathartics are often associated with diuretics, as calomel, squill, and digitalis, or with the bitartrate or sulphate of potash. The diseases in which their exhibition is most clearly indicated are inflammation of the brain or its meninges, inflammation of the liver and of joints, and catarrhal attacks of the throat or lungs. They are contra-indicated in all cases where there is inflammation of the gastro-intestinal mucous membrane or the peritoneum, or where the patient is enfeebled by exhausting disease. Cathartics, I feel confident, are greatly abused. Except in early dropsical accumulations and active intracranial inflammation, energetic purgatives should be given with great reserve.

Mercurials demand more than a passing notice, having been greatly abused

in the past, and being greatly slandered at the present time. As cathartics they are among our most certain remedies; as correctives of vitiated secretions, especially the intestinal and hepatic, they have no rival; as aplastic or defibrinating agents, they are most potent; and as sorbefacients, capable of disposing of inflammatory products, they are invaluable notwithstanding all the opposition encountered. I should regard their proscription as a public calamity. They are adapted to every stage of inflammatory disease: at the commencement, to remove all offending matters from the bowels; and afterwards, to establish the healthy action of the glandular apparatus of the skin and mucous membranes, kidneys, and liver; and also to subdue vascular excitement. The last effect is probably due to their antiplastic influence upon the blood, by which it is made less stimulating to the ganglia which influence the action of the heart and arteries. At a still more advanced stage, and indeed after the inflammation has declined, their value is conspicuous in preventing structural change by resisting the production of fibrin, or by effecting its removal when once deposited. The diseases over which they exercise the greatest control are inflammation of the serous and synovial membranes, as the pleura, peritoneum, and the lining membrane of the articulations; inflammation of certain mucous membranes, as those of the larynx and trachea; inflammation of the brain and its membranes; hepatitis, iritis, endocarditis, and syphilis in many of its manifestations. The preparations most desirable for use are calomel, corrosive sublimate, and blue mass. When a gentle cathartic action is desired, three or four grains of calomel, with the same amount of pulverized rhubarb, will generally secure this result; or six or eight grains of blue mass, followed in two or three hours by a Seidlitz powder, will act in much the same way. Where our object is to control inflammatory action, or its results, the dose should not exceed one-fourth of a grain of calomel, or one grain of blue mass, to be given according to the urgency of the case,—every hour it may be in some cases of croup, where minutes count as days. In other affections the value of alkalies as antiplastic remedies suggests their use in conjunction with calomel, as practiced by Dr. Ludlow, of this city; and I have found great benefit result, especially in croup, from administering one-sixth of a grain of the mild chloride of mercury and three grains of the bicarbonate of soda every hour until the disease begins to yield. The bichloride of mercury, either alone or in combination with the iodide of potash, has a more restricted application, being suited more particularly to the treatment of syphilis; and the same may be said of the protiodide of mercury. The tendency of the mercurial preparations to act upon the bowels will render it necessary to associate them, where the specific effect of the drug is desired, with a small portion of opium. Under all circumstances the greatest caution should be observed not to carry the mercurial impression too far. Salivation is rarely, if ever, necessary. Should the gums become inflamed, or any tenderness be experienced when closing the teeth firmly together, or the least odor discovered, the remedy must be suspended at once, or given at such intervals and in such diminished doses as will barely maintain the impression as long as the case may demand. The extreme susceptibility of some persons to the constitutional influence of this remedy requires that the physician should keep the closest watch over his patient.

Anodynes.—These are among the greatest blessings we possess; for there is nothing so much dreaded as pain, and its existence in any great degree always operates to the detriment of a patient. They should always be administered in full doses after operations of any magnitude, when pain is experienced. The relief from suffering and the mental quietude which they induce contribute largely, by keeping in abeyance the nervous system, to counteract inflammation and favor reparative processes. Unless, however, restlessness or pain is present, or is likely to be, I see no indication for their use, and do not advise their administration. It is sometimes a very nice point to determine when they should be given. During the period of sur-

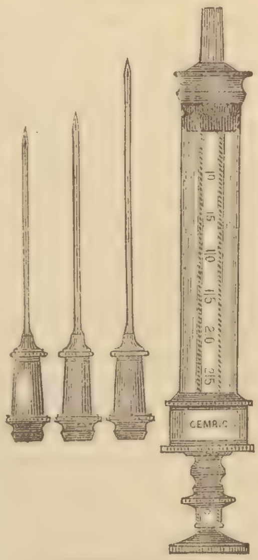
gical or traumatic fever, when the pulse is rapid, the skin hot and dry, the bowels costive, with headache and thirst, the effect of opiates is unpleasant, and they should be withheld until, by the free evacuation of the bowels, and the use of diaphoretics or refrigerants, the circulation becomes quiet and the temperature falls. If it is considered desirable to use them during this stage, by reason of pain or great nervous disturbance, they may be given most advantageously in combination with such articles as tend to increase the activity of the kidneys and skin. The following formulas embody the best combinations of the kind, in my experience:

℞ Antimonii et Potassæ Tartratis, gr. $\frac{1}{4}$;
Spiritus Ætheris Nitrosi, f℥iii;
Liquoris Morphiæ Sulphatis,
Aquæ Aurantii Florum, āā f℥ss.
M.—Sig. Dessertspoonful in half a tumbler of water every two hours.

℞ Morphiæ Sulphatis, gr. i;
Misturæ Potassæ Citratis, f℥vss;
Curaçoæ, f℥ss.
M.—Sig. Dessertspoonful every two hours.

After the stage of excitement is past, or when suppuration is established, anodynes are generally well borne. In intracranial inflammations their use is interdicted by some authorities; but I have never seen any effects, when they have been employed under such circumstances, calculated to shake my confidence in their value: on the contrary, after depletion by bleeding or purging, and when associated with diaphoretics and diuretics, they are productive of great good.

Fig. 40.



Hypodermic syringe.

The preparations commonly used are opium, morphia, laudanum, deodorized tincture of opium, liquor morphiæ sulphatis, Dover's powder, and chloral hydrate. With some persons opiates do not act pleasantly, giving rise to sick stomach or headache. With such we can sometimes secure their tolerance by combining with them a little hyoscyamus. One grain of the latter, with one-quarter of a grain of morphia, taken at bedtime, answers a good purpose. Chlorodyne can sometimes be used when all others fail; and the same is true of camphor and lupulin. The hypodermic use of morphia is particularly indicated when the stomach is irritable. One-quarter of a grain placed under the skin by the hypodermic syringe (Fig. 40) will usually produce a prompt impression in a few minutes. When we have to deal with restlessness rather than pain, the bromide of potash or of ammonia, given in twenty- or thirty-grain doses every two or three hours in some mint-water, will be followed by excellent effects; and when associated with five or eight grains of chloral the result will be still more decided.

Tonics.—Remedies of this kind are indicated when the inflammatory symptoms are rapidly declining and the patient's strength begins to fail, or in cases where, the acute stage being past, a chronic condition is threatened, as manifested by a passive congestion of the vessels of the inflamed part, with swelling. What is demanded under such circumstances is tonicity of fibre and a more active exchange of blood. Quinia and the various preparations of iron serve best. The former, though not so agreeable to the taste, should be administered in solution rather than in pill form, and in doses of from ten to twenty grains during the twenty-four hours. Of the iron prepara-

tions the tincture of the sesquichloride is perhaps the most reliable, and should be given in small doses frequently repeated, rather than in large ones at long intervals. Five drops every hour or two is better than twenty drops every three or four hours. Various elixirs of iron are much in use, but are not so reliable as the form described. Some of the vegetable bitter infusions act well, as those of gentian and cinchona. The old Huxham's tincture (the compound tincture of cinchona) is a valuable preparation.

Stimulants.—These, like tonics, are to be used when the system demands support, and should generally be administered with articles of nourishment, such as milk, in the form of milk-punch or wine-whey. Brandy, when pure, is to be preferred; but, if it cannot be obtained, whisky is the next best substitute. When we have to contend with a sick or irritable stomach, champagne will often be found to answer the purpose best. That stimulants are greatly abused in the sick-room there can be little doubt. They are frequently exhibited too early in the attack, or given in too large quantities. The necessity for them must be determined by the effect upon the circulation. If under their administration the pulse becomes less frequent and more full, the skin less dry and the patient more quiet, their use is proper. Whatever of prejudice is arising against alcoholic remedies, it is nevertheless true that they cannot be discarded entirely from the list of our resources without serious injury to the sick. No man can practice his profession long without discovering that in many cases his great duty is to sustain life and patiently wait and watch for the final triumph of what we are wont to call nature; and these are cases demanding stimulants and food.

Diet.—The modern plan of stuffing patients from the very inception of an attack of disease or the reception of an injury is most pernicious, and deserves the strongest condemnation. A sick man with his system aflame with fever, with headache, dry skin, torpid bowels, scanty urine, and a disgust for food, does not want broths and other articles of nourishment. Nature under these circumstances abhors all such things, and the effect of their presence in the stomach and intestines can only be that of a foreign substance, giving rise to additional irritation. Where the symptoms are as above stated, cold water,—with or without lemon-juice,—barley-water, or water containing some toasted bread, or milk, supplies all that is needful. When the period of febrile disturbance begins to subside, indicated by diminished frequency of the pulse, cessation of thirst, moist skin, restoration of the various secretions, and a more natural taste, then is the time to begin the administration of food, such as beef-tea or essence of beef, animal broths, milk, eggs, arrowroot, chicken or beef jellies, ice-cream, and still later, if the digestive organs are in a condition to receive such, cream toast and broiled meats. Nourishment should be given at stated intervals, like medicine, and not irregularly.

Ventilation, etc.—Attention should be paid to the condition of the atmosphere of the sick-room, taking care to see that it is kept pure by the free admission of fresh air, the prompt removal of all soiled dressings and of dejections, the use of disinfectants, change of under-garments and bed-linen, the maintenance of a proper temperature,—not exceeding 68° or 70°,—and the allowing of no more persons in the room than are necessary to supply proper attention to the patient. Unless there be reasons to the contrary, as when there is inflammation of the eyes, or of the brain or its membranes, a free admission of light is desirable.

Nurses should be quiet, self-possessed, orderly, cheerful, and not given to whispering or to loud talking; they should possess the very rare tact of accommodating themselves to the whims and peculiarities of the sick, controlling or restraining them with such delicacy and kindness of manner as to conquer without opposition and to secure at once their confidence and good will.

Having thus detailed the extent of our resources with which to combat inflammation, it is proper to state that in a considerable proportion of cases we find no necessity to do more than enjoin rest, together with cool anodyne

lotions, a refrigerant mixture with a little morphia, and proper attention to the bowels and diet. Just so long as the natural resources of the system appear equal to the emergency, it is the duty of the surgeon to look on, carefully watching the progress of the case, and not presuming to interfere until these show signs of failure. He is a rash practitioner who is not content to be the servant of nature and quietly wait until her voice is raised for help.

CHRONIC INFLAMMATION.

Chronic inflammation presents certain phenomena quite unlike, in many particulars, those of the acute form of the disease. In some instances the latter passes into the former either as a result of timid treatment or from favoring conditions of the general system; in others the process is wanting in active demonstrative features from the beginning. So subdued and insidious is its course in some cases that much structural damage may be effected before even its existence is recognized. How often do we see extensive change in the hip-joint occurring before inflammation has been suspected! The same may be said of the liver; cirrhosis may be far advanced and yet escape the notice of the physician; and the pleura may also be the seat of inflammation, followed or not by effusion, and yet its existence be entirely overlooked. It is astonishing how uncomplaining the tissues and organs of the body are when quietly invaded. The morbid changes are effected so slowly and imperceptibly, without coercion, that the healthy and unhealthy consort together with a degree of tolerance which may mislead both the patient and the practitioner.

Symptoms.—The phenomena which declare the existence of acute inflammation are also present in the chronic variety, but in a greatly modified form, as follows:

Change of color.—Instead of the red crimson blush of the former, the color is reddish-brown, purple, livid, or of a blue shade, the blood finding its way with difficulty through the part, losing its oxygen and assuming the characteristics of venous blood. It is quite common to notice in such parts stains of different hues, due no doubt to the deposition of pigment by the decomposition of blood-corpuscles. Such discolorations may remain long after the disease subsides, and are most commonly seen upon the legs, about the seat of old ulcers. In the negro it is quite common to see, in the vicinity of such ulcers, the pigment completely removed, the parts being unnaturally white.

Heat.—No perceptible rise of temperature, in many cases, will be detected by the hand, although it requires but the test of thermometry to prove that in chronic inflammation it is really elevated.

Pain.—This is dull in its character, the patient often complaining only of soreness in the parts involved.

Swelling.—This is the result of the effusion of serum or lymph. Generally it takes place slowly, and imparts a marked degree of hardness or induration to the affected parts. This condensation, unless the disease be controlled, tends to spread to the surrounding structures, some distance beyond the original seat of the disease, and destroys the pliancy and mobility of the tissues. The embarrassment to the venous circulation by this induration produces œdema in the parts contiguous. When serous tissues are attacked, such as the synovial membranes of a joint, or the peritoneum or pleura, the exudation consists largely of epithelial desquamation and serum, constituting dropsies; when mucous membranes become the seat of such inflammation, the swelling will be determined by the depth to which the disease extends. When superficial, there being no obstacle to the escape of the exudation, the consistence of the latter will be watery, purulent, or muco-purulent, with abundance of epithelium, constituting a catarrhal variety; but when it involves chiefly the submucous or connective constituent, then the intu-

mescence may be great, as is seen in the larynx or trachea, offering serious resistance to the entrance of air by diminishing the calibre of the tube.

Constitutional Symptoms.—In many cases of chronic inflammation there are no constitutional signs detectable; but in others, as where a joint is affected, or a bone or some internal organ involved, there will be restlessness, fever, perspiration, thirst, diarrhœa, and emaciation. The fever may be constant or continuous, or remittent in its type, with exacerbations, perhaps most frequently in the evening.

Causes.—These are either local or general. Of the former, it may be said that whatever overtasks a part or an organ favors the disease. In this way it frequently follows acute inflammation, the part being so enfeebled or crippled as not to be able to recover itself; or, to state the matter in a more definite form, the vessels which have been overstrained by a superabundance of blood in an acute attack have not been able to contract to their normal size, and they continue to be overdosed with blood. Thus a joint once inflamed is prone to recurring attacks upon slight provocations, and in each succeeding one the chronicity is more and more marked. Again, the cause may be due to prolonged functional activity: the stomach, habitually stimulated by food and drinks excessive in quantity or unsuited in quality, from the constant presence of an undue amount of blood necessary to meet the unreasonable demands, becomes chronically inflamed; excessive walking may induce inflammatory softening of the spinal cord, the vessels having been unduly dilated by the constant demand for blood, in order to honor the drafts upon the nerve-centres with which the motor nerves of the lower extremities are related; and the eye, from constant use, may suffer the most serious structural changes.

Among the constitutional causes may be enumerated, diathesis, such as the strumous or syphilitic, in illustration of which we have glandular enlargements, joint and bone disease; peculiar states of the system, such as are present in gouty and rheumatic persons, giving rise to inflammation of the kidneys, bladder, fibrous and joint structures; disease of special organs, as the heart, exciting bronchial catarrh; disease of the liver, inducing hemorrhoids; and, finally, any cause which enfeebles the system, such as protracted fevers.

Pathology.—In chronic inflammation the vessels are found in a state of unusual dilatation, with an increased quantity of blood in the affected part. The anatomical components of the inflamed district are filled with serum and plastic matter, the corpuscular part of which will be found in varying stages of organization,—in one place maintaining the usual form of leucocytes, at another advanced to connective-tissue corpuscles, and at others, again, having reached the stage of true connective tissue. This serves to fuse together the different structures, to destroy or greatly diminish the pliancy of the parts, none of which are proof against infiltration, and to render them thick, resistant, and hard,—a true hypertrophy. The walls of the vessels which traverse the inflamed district become adherent to the structures amidst which they are placed, and are thus rendered unable to contract upon their contents, so that the blood moves sluggishly along their channels and tends to maintain a constant state of congestion. With these changes the normal tissues undergo fatty transformations, completely changing their natural characteristics, and giving the whole a homogeneous, whitish appearance. This is well exhibited when cutting into the soft parts overlying a bone which has long been affected by necrosis.

The phenomena differ much in different tissues, according as the serum or the lymph predominates. Thus, in mucous membranes, in addition to infiltration, there may be increased glandular activity, manifested by profuse secretion; and there will often be a rapid formation and an equally swift desquamation of the epithelial cells, while occasionally, also, an imperfectly organized or false membrane is formed. When serous or synovial structures are attacked, such as the pleura, or a joint, should the serum be in excess, it will form interpleural dropsy (hydrothorax), or hydrops articuli; but should the plastic or fibrinous element dominate, there will be thickening from the

formation of connective tissue, which either adheres to or becomes blended with the serous membrane. Under the same condition bands of a similar nature may intersect the cavity of a joint, abridging its movements, and giving rise to a form of anchylosis. Another condition, often seen in diseased joints, with sinuses in the soft parts, is the formation of badly-organized granulation-tissue or fungosities. Suppuration or the formation of pus may take place in a chronically inflamed part, and when inclosed in a proper membrane it constitutes a cold abscess.

Treatment.—The indications are, first, to remove the cause, to ascertain which the most searching scrutiny must be instituted; and, second, to restore the parts involved, as much as possible, to their original condition. To effect these ends the treatment is divided into constitutional and local.

CONSTITUTIONAL TREATMENT.—The surgeon must first make a general estimate of the case with which he has to deal, just as a civil engineer takes a sweeping survey of the topographical features of a locality before he elaborates the details of his work. Among these preliminary considerations will be the age, sex, social condition, habits, antecedents, vigor or feebleness of the patient, duration of the disease, etc. The surgeon should never forget that chronic inflammation is not, like a mathematical statement, a fixed quantity, but is a condition of degrees, and therefore demands a treatment more or less energetic.

Rest.—This is often of primary importance; and by rest I do not mean freedom from all motion, but from all voluntary motion. A patient with a chronically inflamed knee- or ankle-joint should not exercise on the limb, but it does not follow that the articulation should not be passively moved; a patient may be allowed to ride out in the open air with a fixed joint, when it would be obviously improper for him to walk.

Diet or regimen.—This must be regulated with special reference to the case in hand. If the system is exhausted, either by disease, destitution, or bad habits, the diet should be generous, such as fresh meats, milk, eggs, substantial broths, and occasionally wines, brandy, or malt liquors. If, on the other hand, the patient has been a full, free liver, the diet should be more restricted and unstimulating, consisting of light broths, farinaceous articles, and milk.

Medicinal agents.—In patients who have previously indulged freely in table excesses, the use of cathartics will be found necessary, such as blue mass followed by a dose of magnesia, sulphate of soda, citrate of magnesia, or the compound cathartic pill. In asthenic cases, a rhubarb pill, or a Seidlitz powder, will fulfill the purpose very well.

Mercury is among our most valuable resources. We have no remedy which so modifies or arrests inflammatory phenomena, or which so certainly insures the removal of inflammatory products, as this much-abused agent. In strumous, tubercular, or broken-down constitutions its use is improper. The preparations best suited for administration are calomel, blue mass, and the bichloride. Here, as in acute inflammation, they should be given in small doses frequently repeated, as one-fourth of a grain of calomel, or one grain of blue mass, or the sixteenth or twentieth of a grain of the bichloride, three or four times a day, restraining their cathartic tendencies by the addition of a small quantity of opium. They should never be carried to the extent of salivation. In cases of irritable stomach, mercury may be often advantageously introduced into the system by inunction. Sometimes, associated with iodine, as the protiodide of mercury, it will be found useful, in doses of half a grain two or three times a day.

Iodine, in some of its forms of preparation, as the tincture, or solution (Lugol's), or in combination with potassium (iodide of potash), is another valuable alterative. The last has been for years a very popular remedy, and deservedly so. It may be given in doses of from five grains to one drachm three times daily, and should be largely diluted to prevent irritation of the stomach. In exhibiting this, or any other alterative preparation, I much prefer small doses frequently repeated: for example, instead of giving three

ten-grain doses (thirty grains) during the day, I prefer the same amount in six doses of five grains each. By such a plan I feel assured that we obtain more certainly the constitutional influence of the drug, without offending the stomach or disturbing the digestion.

Cod-liver oil forms another remedy of great value. Its beneficial effects are most noticeable in children, although it is not without good results in the middle-aged and the old. Whenever there is debility, with loss of flesh, or a strumous vice of organization, such as is seen in pale children with swollen glands and purulent discharges from the mucous membrane of the nose, it will rarely disappoint us, provided the stomach will tolerate its presence. Its efficiency will be increased by the simultaneous exhibition of the iodide of iron, either in syrup or in pill. The oil should be given one hour after meals, and in doses of from one teaspoonful to a tablespoonful.

Tonics form an important part of our remedial resources. Where the digestion is feeble, or the patient anæmic, or exhausted by the long continuance of disease or from the effects of injudicious treatment, they fulfill a valuable purpose. Those most worthy of notice are the compound infusion of gentian, —with or without the addition of the tincture of nux vomica,—quinine, compound tincture of cinchona, tincture of the chloride of iron, nitric or nitro-muriatic acid. Where the digestion is somewhat impaired, with want of appetite, and where mercury is not contra-indicated, the bichloride may be given with great advantage with the compound infusion of gentian. The following formulas may be used:

℞ Tincturæ Nucis Vomicæ, gtt. lx;
Infusionis Gentianæ Compositi, f℥vi.
M. Sig.—Dessertspoonful every four hours.

℞ Acidi Nitrici, gtt. iv;
Infusionis Gentianæ Compositi, f℥vi.
M. Sig.—Tablespoonful before each meal.

℞ Hydrargyri Chloridi Corrosivi, gr. ss;
Infusionis Gentianæ Compositi, f℥vi.
M. Sig.—Dessertspoonful four times a day.

LOCAL TREATMENT.—In many cases local treatment is all that will be required. Among the most important of this class of remedies are the following:

Removal of the cause.—Whenever practicable, this should take precedence of all else. If a sequestrum of bone has provoked the inflammation, it should be taken away, and the disease will disappear. If the eyelashes are inverted, change their direction, and the cure is assured.

Local bleeding.—To unload the vessels of a part already surcharged, is to diminish transudation and modify its nutrition. Blood may be taken by scarifications, incisions, cups, and leeches. Incisions not only deplete the blood-vessels, but also drain away the interstitial deposits, especially those of the more liquid kind, such as serum.

Blisters, by producing a large flow of serum, and by the new action which they excite, are sometimes desirable. They may be large, covering directly the diseased part, or they may be small and frequently repeated, either over or at a little distance from the affected region. They are used with the greatest benefit after the abstraction of blood.

Counter-irritation, by means of stimulating liniments, such as the linimentum saponis, or by mustard-plasters, will occasionally prove serviceable, by diverting the blood from the deeper parts.

Alteratives, as the mercurial ointment, iodine ointment, tincture of iodine, and nitrate of silver, are often very useful.

Setons and *issues*, though far from being popular at the present time, are capable of doing great good, and will by-and-by be better appreciated. I believe they are capable of accomplishing all, and more than all, that is

claimed for the actual cautery. They should be placed at some distance from the diseased locality, yet not so far as not to influence its circulation. They should not be allowed to extend deeper than the subcutaneous cellular tissue. The seton may consist of a single thread introduced by a needle, the latter withdrawn and the ends of the thread knotted together; or an entire skein of silk may be used, the insertion of which can be effected either by a seton needle (Fig. 41) or by raising between the thumb and fingers a dupli-

Fig. 41.

Seton needle armed with silk.

cation of integument, pushing a straight, sharp-pointed bistoury through its base, and then conducting along its blade a probe, armed with the seton. The favorite localities for the introduction of such are the back of the neck, the side of the thorax below the axilla, and the inside of the thigh. The irritation which follows its introduction is best allayed by means of a warm-water dressing or a poultice of flaxseed meal, until suppuration is well established, after which the seton should be gently moved, and cleansed with warm water and soap daily, covering it over with a pledget of lint, and securing the dressing with a strip of adhesive plaster.

The issue is established by covering the surface selected with a piece of adhesive plaster, having an opening cut out of the centre half an inch in diameter, in which is placed a piece of caustic potash the size of a small pea and covered in with another piece of plaster. In two or three hours a slough will be produced, the separation of which is facilitated by a poultice. This ulcer is kept open by inserting into it a pellet of lint smeared with savine ointment, or a lentil bean, keeping either in place with a dressing similar to that described for the seton.

Moxa.—The application of the moxa is not much used at present. Moxa may be made very readily by wetting some lint or cotton with a saturated solution of nitrate of potash, and then rolling it into a conical-shaped mass. After drying it is ready for use. It is occasionally prepared from the medulla of certain plants, which burns slowly after being dried; also from the fungoid growths which are attached to decaying trees. In its application, the moxa should be supported in an instrument (Fig. 42) called the porte-moxa, the

Fig. 42.

Porte-moxa.

apex of the cone to be ignited and its base placed upon the skin. The heat gradually reaches the part, and as the fire approaches the base of the moxa the pain becomes intensely severe.

Irrigation and pressure.—The constant application of cool water by means of an irrigating apparatus,—already described under the head of local remedies in acute inflammation,—especially when conjoined with pressure by means of a firm roller, constitutes a method of removing inflammatory products, and thereby the swelling and induration, in chronic inflammation, unsurpassed by any other. By this plan, in ten days I have succeeded in reducing a limb measuring twenty-three and three-quarter inches in circumference to nineteen inches.

Pressure alone, by a roller, elastic bands, or adhesive strips, will likewise prove efficacious. By either plan the vessels are compressed, the amount of blood diminished, and transudation prevented, while the imperfectly organized materials deposited in the midst of the tissues undergo such retrograde changes as insure their removal.

Manipulation—that is, rubbing, kneading, and moving the part with the fingers—forms another valuable resource. It is best adapted to cases in which the inflammatory action has in a great measure subsided, leaving the tissues thickened, matted together, and stiff.

Electricity and *galvanism* possess a certain degree of discussing power over the structural changes of chronic inflammation; but I confess that I have not seen any uniformity of action in this direction.

There are also agents which, by virtue of their action upon the living walls of the vessels, excite contraction, diminishing thereby the size of their channels, and thus preventing undue vascularity. Such are astringents, as the sulphate of zinc, acetate of lead, nitrate of silver, alum, etc. These remedies are best adapted to the inflammation of mucous membranes, as the conjunctiva.

In addition to the two general divisions of inflammation of which we have now treated, it is proper to state that other varieties are recognized among writers, arising in consequence of peculiar conditions of the general system, or from the presence of a dyscrasia. Thus, we have erysipelatous, strumous, tubercular, syphilitic, rheumatic, and gouty inflammation. These I regard in the light of complications, and believe their recognition to be of importance, as it enables us to modify the treatment,—as, for example, in erysipelatous inflammation we never lose sight of the tendency to form subcutaneous abscesses; in strumous, tubercular, and syphilitic inflammation, the necessity for tonic and alterative combinations must be kept in mind; and in the rheumatic and gouty variety, we must attend to the depuration of the blood, through the kidneys and other secretory organs. This, however, is not the place to discuss such complications.

Effects or Results of Inflammation.—The results of inflammation are simply those materials which pass from the blood-vessels into the midst of the tissues. They are sometimes spoken of as "effusions," as those materials which "infiltrate the tissues," at other times as "inflammatory exudations," or "transudations." They consist of *liquor sanguinis*, *blood*, and *pus*.

1. *Liquor sanguinis*.—This is the liquid part of the blood, consisting of fibrin, albumen, water, earthy and alkaline salts, and in which—in circulating blood—float the corpuscles. It is coagulable by heat and acids. External to the vessels the liquor sanguinis may lose fibrin and a part of its corpuscles, and appear as a colorless, watery fluid, called *serum*, and hence many authors speak of the transudation of the latter as a product distinct from the former; but, as we never find serum entirely free from the other constituents of the liquor sanguinis and responding to the same reactions, the transudation will admit of being treated under two varieties, the *serous* and the *fibrinous*, the chief difference being in the amount of fibrin respectively contained. Mr. Paget uses the terms "corpuscular" and "fibrinous;" Rokitansky, "croupous" and "fibrinous;" for the latter. Prof. Gross employs the word "*lymphization*." Others have designated these two varieties "*aplastic*" and "*plastic*."*

a. Serous variety.—This may appear very rapidly and in great abundance, a few hours only being sufficient to fill the cavity of the pleura or of a joint, or its production may be slow and almost imperceptible. It follows both acute and chronic inflammation, but most commonly the latter. Different structures, when inflamed, furnish it in widely different degrees. Connective tissue yields the largest amount: hence its abundance in fascial and serous inflammations. Mucous membranes may pour it out from their free surfaces, in which case it contains leucocytes, epithelial cells, and increased glandular secretions, as seen in the early stage of inflammatory attacks of the Schneiderian membrane of the nasal cavities, and in cholera; or it may accumulate in the submucous stratum of connective tissue, as in œdema of the glottis. Serum is frequently mixed with other materials, which change its color. Thus, in ascites, hydrocele, and some cysts, it is of a yellow or straw color;

* Williams's Practice of Medicine.

in cold abscesses it is sometimes seen as a whey-like fluid, containing cheesy particles or masses of depraved fibrin. Occasionally it has a red or reddish-brown appearance, due to the presence of blood, in consequence of rupture of contiguous vessels.

The presence of serum is not always an evidence of inflammation. To some extent it is always passing through the walls of the vessels and bathing the tissues. The normal moisture or succulence of cellular tissue is due to its presence; it is needful for pliancy, and fulfills, in some degree, the office of a lubricator to the component parts of such structures, as the synovial fluid does to joint-surfaces. It may appear also as the result of purely mechanical obstruction, as seen in the swollen limbs of the pregnant female from the pressure made by the gravid uterus upon the ascending cava, or in the arm when a tumor presses against the axillary vein. When diffused through the cellular tissue it constitutes anasarca. Pressure made upon such a part leaves, when removed, an indentation or depression. When serum accumulates in a serous or synovial cavity it forms dropsy, as abdominal dropsy or ascites, joint dropsy or hydrops articuli. This variety of transudation, so deficient in fibrin, possesses little or no power of organization.

b. Fibrinous variety.—The other form of liquor sanguinis transudation is characterized by a large amount of fibrin, and tends to organization. It is more especially the product of acute inflammation occurring in sound, vigorous constitutions. Its production is not alike in all tissues of the body. In inflammation of the serous membranes, such as the pleura or peritoneum, it appears quickly and in abundance, presenting usually one of three conditions: 1st, studding the surface of the affected membrane with a kind of frost-work roughness; 2d, in the form of bands and thread-like reticulations, limiting the movements of the contiguous layers of the membrane; and, 3d, uniting solidly together these layers by an intermediate tissue, and preventing all motion between them. These appearances are quite familiar as a result of pleurisy.

Mucous membranes when inflamed yield a transudation similar, and not inferior in quantity, to that of serous membranes. A notable example of this exists in croup, in which disease it is not unusual to see the fibrogenous material deposited as a membrane of almost leathery consistence, or even forming a perfect cast of the tracheal tube. Organs of a very compact construction, such as bone or tendons, when inflamed, yield a comparatively small amount of fibrin.

Between these two varieties of the liquor sanguinis—serous and fibrinous, the first containing many organic forms but little fibrin, the second, much fibrin—are many intermediate grades of this transudation; a fact which depends upon the intensity of the inflammation, the condition of the blood, the constitutional integrity of the patient, and the tissue involved. The same conditions determine the fate of the transudation, whether it will end in reabsorption, organization, or suppuration.

Inflammatory transudations differ essentially from those which take place as the result of blood-pressure from mechanical causes, such as follow the contact of a tumor with a great venous trunk; differ much from the constitution of the blood in the vessels of an inflamed district. This difference consists in the amount of both organic and inorganic constituents,—the former possessing a vast increase in cell organisms and an increased amount of the chloride of sodium and phosphates, the latter closely resembling serum. This increase can be accounted for only by the metamorphosis of the tissues inflamed. The proof of this statement will appear by an examination of the organic forms of an inflamed part, and by the analysis of the fluid which streams from a recent wound, such as that which soaks the dressings first removed from a stump after amputation. The cell constituents are migrated leucocytes and connective-tissue corpuscles, the latter passing from the stable to the mobile condition.

This fibrinous exudation may work either good or evil. Among its friendly

offices is the repair of parts which have been injured either by the knife of the surgeon or by accidental violence; wounds are reunited, broken bones solidly joined together, depots of pus encapsulated, and foreign bodies become encysted to remain harmless in the midst of the tissues. On the other hand, mucous canals, such as the urethra or the lachrymal sac, may be narrowed or obliterated, forming strictures or fistules; joint-surfaces may be united, producing anchylosis; opacities may result, destroying the transparency of tissues, as the cornea, and so damaging the vision; together with many other structural changes with which every surgeon is familiar.

2. *Transudation of blood.*—Inflammatory exudations are mingled with blood-corpuscles, the coloring-matter of which often gives a peculiar shade to the material. Their presence is due both to migration and to rupture of the old or new vessels, the walls of which have been over-distended, or softened to such a degree as to be unable to withstand the pressure of the blood-currents. It may amount to a real hemorrhage, and by its presence disturb the favorable progress of the case. There is no reason to believe that these red corpuscles play any important rôle in the work of organization or repair.

3. *Suppuration*, by which we mean the formation of pus in a part, is one of the most common results of inflammation. This material is one with which the surgeon has much to do.

What is pus? As seen when taken from an acute abscess in a healthy person, it is a yellowish-white fluid, with often a greenish shade, apparently homogeneous, of a creamy consistence, unctuous or viscid to the touch, having a sweetish taste, almost free from odor, with a neutral reaction, and a specific gravity ranging from 1021 to 1040.

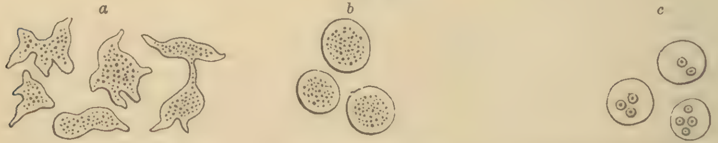
If this fluid be placed in a test-tube and allowed to stand for a time, it will separate into two portions,—an upper, clear, thin layer, which is serum, liquor puris, or intercellular material, and a lower portion, having a yellowish color and more consistency, which consists of cells, pus-cells.

The chemical composition of pus, in consequence of the contained protean matters, has not been absolutely determined.

The serum or pus-liquor holds in solution the same materials as the serum of the blood, *i.e.*, water, albumen, mucus, extractive matters, fat, and different salts,—principally chloride of sodium. Besides the constituents above mentioned, pus is now known to contain several other matters, such as pyin, paraglobulin, myosin, tyrosin, fatty acids, and leucin.

Microscopical appearances.—When a portion of pus is placed within the field of the microscope, it is seen to consist of cells from $\frac{1}{3500}$ to $\frac{1}{25000}$ of an inch in diameter, having various forms, and filled with minute granules. These cells possess amœboid movements, and are really living organisms (Fig. 43).

FIG. 43.



a, Living pus-corpuscles. *b*, Dead pus-corpuscles. *c*, Dead pus-corpuscles treated with acetic acid, showing nuclei.

If a little dilute acetic acid be placed upon the slide, the granular particles quickly disappear, and the nuclei—from one to four—come out clearly defined; after which, if an alkaline solution be added, the entire cell disappears.

Although these bodies are living organisms endowed with the power of growth, multiplication, and locomotion, and with a capacity to assume various forms, yet, as we see the corpuscles when taken from abscesses, most of them have lost these attributes, are dead, and, either within or without the body, have become the prey of destructive chemical action.

Pus having the characteristics described is termed *healthy* or *laudable pus*; but from modifying circumstances other varieties are recognized, as follows:

1. *Ichorous*,—when it possesses but little consistence, being thin, and irritating or excoriating the parts with which it comes in contact. Open cancers and gangrenous tissues supply pus of this nature.

2. *Sanious*,—when it is mingled with blood, presenting a mixture of dark red and yellowish-white or straw color, and often exceedingly fetid, such as flows from old ulcers or sinuses leading to diseased bone, and which frequently contain bone salts, especially those of lime.

3. *Curdy or scrofulous*,—when thin or whey-like, and containing cheesy flakes or little masses of caseous-like matter. Cold abscesses, abscesses of lymphatic glands, and joint disease furnish good examples of this kind.

4. *Muco-pus*,—when whitish and slightly ropy, being a mixture of mucus and pus. This variety is often seen in chronic inflammations of the bladder, or of the nasal mucous membrane.

5. *Gummy or ropy*.—This variety is frequently seen in syphilitic constitutions, especially in the breaking down of gummy tumors; the fluid is straw color, and has the consistence of thin syrup or gum mucilage. Abscesses which follow the use of hypodermic injections furnish pus of this kind.

6. *Contagious*.—Certain kinds of pus, when applied to the body under favorable conditions, are capable of producing both local and general infection. This is called *contagious pus*. A familiar example of local infection is that from purulent ophthalmia. It is not an unusual circumstance to see large numbers of boys and girls in houses of refuge and homes, attacked by this disease from using the same towels, and even the same basins. Such was the case at the Philadelphia House of Refuge and other public institutions a few years since. Gonorrhœa is another example. In other instances the constitution becomes invaded, as in smallpox, syphilis, glanders, etc. It is not, however, the pus, but most probably certain organic forms or particles of living matter associated with it which poison the general mass of the blood. Burdon Sanderson* and Professor Cohn have shown such forms in vaccine virus, consisting of chaplets of minute spheroids, designated by the latter "*microsphæra vaccinæ*," which, from their capacity of division and their behavior under chemical reactions, are known as micrococci.

A great number of substances may be accidentally mixed with pus, such as the secretions of glands, epithelial cells, shreds of dead tissue, particles of bone or its salts, pigment, and blood. It may contain gases of different kinds, as in abscesses near the rectum,—also certain minute organisms, which in some instances are said to produce a blue color, like that seen in the blue milk described by Lücke, but which would seem rather to be due to a crystalline substance residing in the serum, discovered by Fados, and called *pyocyanine*. This blue pus was seen by Dr. Gibb† in the case of a female whose mammary glands were affected, and, from the changes produced by certain chemical tests, was attributed by him to the presence of cyanuret of iron. His paper contains a record of ten cases collected from various sources. Pus of different shades of color is described by the same writer, such as olive, orange, slate, black, and green. Blood in different amounts, and in different stages of disintegration, will supply many shades of red; and bile will furnish several varieties of a yellow or orange color.

Diagnosis of Pus.—In most cases a simple inspection by the eye will enable us to pronounce with certainty as to the existence of pus in a fluid; yet sometimes it is found mixed with other matters which conceal its presence and demand either instrumental or chemical tests for its recognition. The resemblance between the pus-corpuscle, the mucus-corpuscle, and the white blood-corpuscle is so exact that the microscope has not established any distinction, and their identity is no strange doctrine at the present time.

* Observations on the Pathology of the Infective Processes, Twelfth Report on Medical Affairs, Privy Council, 1870.

† British Medical Journal of Science, vol. vi. page 201, new series, 1850–51.

The addition of liquor potassæ to a fluid in which pus is supposed to exist will, in the event of its presence, produce a thick, ropy, gelatinous condition. No such appearance will follow if mucus alone be present; on the contrary, the fluid will become thinner.

Dr. Day, of Geelong, has introduced a test which deserves notice. It consists in adding a very little water to a fluid supposed to contain pus, and then a few drops of a liquid prepared by exposing to the air an alcoholic solution of guaiacum (saturated) until it acquires the property, by the absorption of oxygen, of assuming a green color when brought in contact with iodide of potash. If pus, however small in quantity, be present, a blue color will be produced. Dr. Day* states that when applied to dried pus of a laudable character the test proves inert, but if the same be moistened with water the characteristic reaction appears. He found, also, that there was a very important difference in the persistence of the susceptibility of different kinds of pus to respond to this test, alleging that pus from phlegmonous erysipelas or carbuncle, however dry, retained the property of answering to the test for months, when moistened; and he attempts in this way to explain the prevalence of erysipelas in moist states of the weather. This test liquid, if kept on hand for any length of time, must be placed in the dark, and in a well-corked bottle, since the air and light induce such changes as render it entirely valueless.

Origin of pus.—This is probably twofold: first, and principally, from the vessels, migrated leucocytes or white blood-corpuscles; and, secondly, from the stable connective-tissue corpuscles, rendered again active by the inflammatory transudation. The pus-cell is undistinguishable from the colorless blood-corpuscle, whether contrasted in size, form, or behavior. In this view of the subject, or in a histological sense, every inflammation results in suppuration or in the formation of pus, but in the technical sense it is the superabounding presence of pus that constitutes suppuration.

Theories of suppuration.—Simpson taught as early as 1722† that pus was formed in the blood-vessels and was therefore a secretion. This view was adopted by Dr. John Morgan, one of the founders of the Medical Department of the University of Pennsylvania, and advocated by him in a thesis in 1763, at Edinburgh, where he obtained the degree of Doctor of Medicine. This thesis was entitled "*Πυοποιεσις*, sive Tentamen Medicum de Puris Confectione."‡ This doctrine of pus being a secretion was embraced by Hunter and accepted generally by the profession of Europe. Hunter did not believe that pus, as such, existed in the blood, but held that it was formed by certain changes or new combinations which it underwent while passing through the vessels. For these changes he supposed some alteration in the structure and disposition of the old vessels or an improvised system of new ones,—something, it is presumed, like the so-called "*pyogenic membrane*" of the French.

Gendrin, in his "Anatomical History of Inflammation" (1826), speaks of seeing the blood-corpuscles when becoming stagnant in the mesentery of the frog gradually change into pus, by losing their coloring envelope and assuming a yellowish-gray color. Kaltenbrünner not only saw and described what was seen by Gendrin, but affirmed that the solids participated in the purulent product, as numerous granular particles were observed to separate from the parenchymatous structures of the parts inflamed and become changed into pus. Is it not probable that in these very early instrumental studies of Gendrin and Kaltenbrünner we have the germs of the modern doctrines of Virchow and Cohnheim, the difference being in the interpretation of phenomena? In addition to the production of pus in the vessels and from the solids of an inflamed part, others, as Carswell,§ believed that blood extravasated in a tissue underwent purulent transformation. Thus stood the subject of pyo-

* Medical Times, March 11, 1871.

† Dissertationes de Re Medica, 1722.

‡ Professor Carson's History of the University of Pennsylvania, page 45.

§ Illustrations of the Elementary Forms of Disease.

genesis until the inauguration of the cell doctrine by Schwann and Schleiden. They assumed the existence of a structureless "*blastema*" or formative fluid, out of which, by the aggregation of particles about a nucleus, arose cells. In this way, according to Schwann, pus-cells originated in the serous transudation consequent upon inflammation. With certain unimportant modifications, this was the doctrine of Hughes Bennett. Paget regarded pus as a degeneration of lymph or dead exudation corpuscles, and Rokitansky believed it to be formed from inflammatory plasma or transudation. With the "cellular pathology" of Virchow was introduced a new doctrine as to the origin of pus; one which confers on this substance the distinction of a young tissue, and makes it the product of the rapid proliferation of connective-tissue corpuscles and epithelial cells. Dr. Lionel Beale gives to the cell masses of living matter the name "germinal" or "formative matter." He combats the doctrine of Virchow, as well as all others which preceded it, asserting that pus consists of germinal masses of matter, which under the stimulus of inflammatory exudation become increasingly active, multiplying and producing, as "formed material," the cell wall and cell contents, except the nucleus. These bodies constitute the pus-corpuscles.

Still later we have the very remarkable experiments of Cohnheim, who, after introducing a coloring substance, such as aniline, into the blood of a frog, found it in the pus-corpuscles of the inflamed cornea of the animal. This fact, together with the migration of the blood-corpuscles observed to take place through the walls of the vessels, constituted plausible ground for the doctrine of the identity of pus-cells with the white corpuscles of the blood.

Thus, in summing up this rapid review of pyogenic literature, we have pus-corpuscles viewed as a secretion; as the result of the decomposition or destruction of tissue; as a product from a formless blastema; as derived from proliferation of connective-tissue corpuscles; as born from germinal matter; and as leucocytes or migrated white blood-corpuscles.

In view of all the facts now in our possession, there can scarcely be a doubt that pus is derived from two sources, namely, the white blood-corpuscles and the corpuscles of connective tissue. Billroth, Von Recklinghausen, Hoffmann, and others, believe that the latter play a very important rôle in the process.

Causes tending to suppuration.—The tendency to the formation of pus varies greatly in different individuals. One person may be the subject of an extensive inflammation terminating by resolution, while in another a very slight attack is followed by suppuration. One man undergoes an amputation, and the wound heals almost by the first intention, while a second, whose constitutional organization apparently does not differ from that of the other, will, after a similar operation, have a suppurating wound for weeks. The cause of such diversity can only be referred to peculiarities of constitution which lie beyond our knowledge. In some instances the cause is apparent from the existence of a scrofulous or tuberculous diathesis; or it may be found in an overwhelming inundation of the inflamed tissue with transudation, for experience has shown that the more abundant the infiltration the more probable will be the production of pus.

A third cause is to be found in the character of the inflammation, as when a part is invaded by erysipelas, in which disease the tendency to suppuration is very marked.

A fourth cause is the entrance into the system of certain septic ferments, as in smallpox, in consequence of which the most extensive suppurations follow; or, indeed, of any poisons, whether applied to the surface, as in purulent ophthalmia, or which internally admitted so modify the blood as to induce an asthenic state of the system. A familiar example is seen in the abscesses following typhoid fever.

A fifth cause is in the tissue involved. Mucous membranes, ordinarily, when inflamed, tend to suppuration,—as shown in catarrhal attacks of the air-passages.

A sixth cause is mechanical irritation, such as results from the presence of any foreign body in the tissues. In this way a ball, portions of clothing, or dead fragments of bone, will excite suppuration. Thus also may vast numbers of abscesses be formed in the internal organs by disintegrated masses of a thrombus plugging up the minute vessels into which they are carried by the circulation. Subcutaneous wounds, such as are made in the division of tendons and fascia, have little tendency to suppurate: the exclusion of air, with its germs, perhaps, explains this fact.

Tissues in which suppuration occurs.—Wherever we find cellular tissue there may we expect suppuration. The more abundant this tissue the more likely is inflammation to result in this manner. Structures in which connective tissue is absent, such as cartilage, do not suppurate; a ball lodged below the deep fasciæ, or even in internal organs, is more likely to become encysted than when subcutaneous. I can conceive of no reason for this except the comparatively small amount of connective tissue existing in and between muscles or uniting the components of other organs. Subcutaneous abscesses are far more common than deeper collections of pus.

Inflammation of mucous membranes results in suppuration very quickly. Serous membranes when inflamed tend either to adhesion or to serous effusion. If an inflammation attacks the mucous membrane of the nose or of the bronchi, a few hours are all that is necessary to produce suppuration; but if the pleura should be the seat of inflammation, in the same length of time the two layers, costal and pulmonary, will either be glued together by lymph or pressed asunder by serum.

This fact, then, that the more abundant the connective tissue the more common the suppuration, is strongly corroborative of the alleged part which connective-tissue corpuscles play in the formation of pus.

Absorption of pus.—Pus once formed in a part may disappear in three ways: 1, it is possible for many of the corpuscles to re-enter the vessels; 2, others may become stable connective-tissue corpuscles; and, 3, the serum may enter the vessels, leaving the corpuscles behind, which, forming a cheesy pulp or emulsion consisting of granules, fat, and other débris of both cells and tissue, may be entirely removed by the vessels, or, when not in large amount, become converted into a cretaceous mass by the deposition of the salts of lime.

Value of suppuration.—Among the older physicians much importance was attached to suppuration, believing, as they did, that such a discharge, whether spontaneous or artificially produced, served to eliminate matter prejudicial to the well-being of the body, depurating the blood, and attracting disease from internal organs; and hence, with this school, setons and issues played an important part in the treatment of affections of the lungs, liver, and brain. I am convinced, from personal observation, that they often work great good in chronic inflammations where the patient's strength has not been too much impaired, not by depurating the blood, but by acting as counter-irritants and depletents.

There is a wide-spread impression also that pus is frequently a vicarious discharge, attracting disease from other organs, and that therefore no attempt should be made to arrest its flow. Hence the care with which pustular eruptions upon the scalp of children, fistulas, and old leg-ulcers are often cherished as safety-valves to the system. I have been unable to discover any such relation, and have never seen any evil results from their cure. Pus when pure furnishes protection to granulating surfaces, but perhaps its most wonderful property is seen in the channeling which it effects between distant points, and by which it is conducted harmlessly out of the body.

Signs of suppuration.—Generally suppuration is preceded, at least in all acute forms of the disease, by well-marked inflammatory phenomena, such as redness, pain, heat, and swelling.

Redness.—This symptom is at first quite intense, but changes as the process advances, the color becoming darker, and almost purple. The skin assumes a smooth, glossy appearance, the parts around when pressed upon are œdema-

tous, and this is especially true if the pus is situated at a distance from the surface or underneath the deep fasciæ. A sallow or cream color is also a frequent characteristic of deep abscess. Suppuration of an internal organ may give rise to periodical redness; for example, the evening flush in certain diseases of the lungs.

Pain.—This, like the pain of inflammation, differs according to the nature of the structure involved. When deep tissues are attacked, it is a dull, heavy ache; in other cases it is acute and lancinating, as in abscess of the mammary gland; or throbbing and pulsatile, with a feeling of great tension or fullness of the part, as in felon. When the suppuration is mature the pain usually ceases. The pain is sometimes periodical, as in disease of the bones or joints, coming on in the evening and continuing for several hours.

Heat.—The temperature of the part, at first high, diminishes after the suppuration is well established.

Swelling.—The degree of alteration of form will be determined by the resistance encountered from depth of structure and the more or less compact nature of the tissues involved. When the matter is deeply placed, little or no swelling may appear externally, and the only evidence, aside from the previous history, will be a brown or leaden color of the skin, with œdema, and at some point diminished resistance to pressure. The more abundant and loose the connective tissue the greater will be the swelling. The prevailing form, however, when not resisted by peculiarities of structure, is a *conical* one. The exact situation of a purulent accumulation is often revealed by its form, as in the submaxillary region when outlined by the attachments of the submaxillary fascia, or by the point at which it seeks to be discharged, as at the outer side of the crural arch in psoas abscess. The tendency of pus to seek the surface of the body is one of the remarkable facts connected with its history. It cannot be explained by the theory of its taking the direction of least resistance. If so, why should an abscess of the liver tend to the surface of the abdomen rather than into its cavity, or one below the deep fascia of the neck to the surface rather than towards the thoracic cavity? Rindfleisch* ascribes it to the diffusion of connective tissue, which is itself capable of being resolved into pus; but the explanation is defective: it will not account for the external discharge of either a hepatic or a pulmonary abscess. It is sometimes called the intelligence of matter. I know of no such material endowment aside from the operation of a law of conservation impressed upon every part of the body by its Divine Maker.

The progress of suppuration towards the surface renders the part acuminate, or forms what is termed "*pointing.*" It is rare for superficial abscesses to have more than one place of pointing: deep ones may have several. At the summit of the elevation the skin is very thin, of a purple or yellow color from the pus being visible, devoid of sensibility, and finally gives way, allowing the contents to escape.

Fluctuation.—As suppuration advances there is an alteration not only of form but also of *consistence.* The swelling becomes softer as the tissues become fluid, and when subjected to certain manipulations yields the sensation of fluctuation. There are three methods of ascertaining the existence of fluctuation, namely, *palpation*, *alternations of pressure*, and *triple pressure.* The first is accomplished by placing one or more fingers lightly upon one side of the swelling, and tapping or percussing the opposite side with a single finger of the other hand. The second, by placing one or more fingers of the two hands on opposite sides of the swelling, and alternately making pressure: as the fluid is displaced by one hand the wave is felt by the other. The third method, and the one which is best adapted to small accumulations, consists in embracing the swelling between the thumb and fingers of one hand while the summit is pressed by a single finger of the other. For large collections, either purulent or serous, the first is the most positive, but for small ones the second and third are to be preferred. Tact is requisite in the practice of all, and is

* Pathological Histology, Translation, Phila., 1872, page 113.

attainable only by practice, the secret consisting chiefly in delicacy of touch and contact.

In chronic or cold abscesses the local phenomena may be entirely wanting, the process being slow and insidious, while the constitutional ones after the suppuration is established assume the gravest character.

Constitutional Signs.—Suppuration, when extensive, or in parts endowed with peculiar sensibility or possessing much resistance of structure, gives rise to well-marked constitutional disturbance. When the transudation assumes the suppurative transformation, the patient experiences rigors alternating with heats, fever, and profuse sweats. These rigors in deep abscesses may return at regular periods with the uniformity of an intermittent. The severity of both constitutional and local symptoms depends much upon the location of the disease. When suppurative inflammation takes place in the ischio-rectal fossa, under the temporal fascia, in the tonsil, or under the post-auricular aponeurosis, we may have a rapid pulse, dry tongue, dry, burning surface, incessant thirst, great restlessness, and delirium, with diminished renal and other secretions. When suppuration is prolonged, even though not very abundant, it makes a profound impression upon the system. The face becomes pale, the palms of the hands and soles of the feet burn, the pulse is frequent, a steady emaciation goes on, the appetite fails, the cheeks glow with an unnatural redness, there are evening or night sweats, perhaps diarrhœa, and, indeed, all those symptoms which characterize hectic fever.

Diagnosis.—The recognition of an abscess is not always an easy task. The most egregious and not unfrequently fatal mistakes have been made, and not a year passes that I do not witness such errors. The usual characteristics of acute abscess, such as change of color, pain, swelling, pointing, and fluctuation, are not peculiar to this disease alone, but are met with in other affections. The conditions most likely to be confounded with abscess are serous accumulations either as an infiltration or in the form of cysts, aneurism, encephaloid growths, adipose tumors, and hernia.

There are certain localities very prone to infiltration of serum, as the eyelids, prepuce, back of the hand, and the neighborhood of articulations, and such infiltrations will impart a sensation to the finger simulating fluctuation. These intumescences are unlike abscess in the following particulars: there is no contrast of color, but a uniform redness over the entire surface; there is no pointing, no thinning of the skin; and the swelling is equally yielding at all points.

Cysts may be distinguished from abscess by the absence of any inflammatory history, by their want of color or tenderness, by their slow growth, and by the absence of rigors. When so situated as to admit of the "light" test, they are often found translucent.

Aneurism.—When an abscess forms over some great vessel, as in the axilla, groin, or popliteal space, it will resemble somewhat an aneurism. How shall we distinguish one from the other?

In acute abscess there have been the signs of previous inflammation. Not so in aneurism. This does not apply to cold abscesses; but the patients who furnish examples of the two diseases are very unlike. Pale, scrofulous persons, under twenty years of age, are the subjects of cold abscess, while aneurism occurs in vigorous adults. Both may pulsate, but the pulsation of an aneurism is expansive, or eccentric. I mean by this, if an aneurismal swelling be grasped by the fingers, it will be felt to expand centrifugally in all directions. In abscess, the movement is one of upheaval, produced not by any force within the swelling, but by one exterior to it. It is sometimes possible, by insinuating the fingers beneath, so to isolate an abscess as to remove it beyond the influence of the underlying vessels. Never so with aneurism. Generally in the latter the ear will detect a bruit. Not so in abscess. Pressure on the cardiac side of either an aneurism or an abscess will arrest pulsation, but the former will diminish in size, while the latter will remain unchanged. Pressure on the distal side will increase the tension of an aneurism; it has no effect on abscess. Both aneurisms and certain cold

abscesses, as psoas, when pointing in the groin, can be "reduced,"—that is, their contents pressed out of sight; but when that pressure is removed, the sac of the former will be refilled rapidly, the latter slowly. There will also be a history of bone disease in the latter.

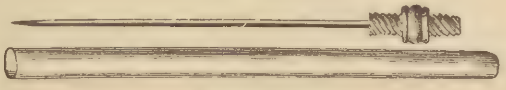
Encephaloid growths, possessing, as they so frequently do, conical projections, with local discoloration and deceptive fluctuation, are not unfrequently mistaken for abscess and laid open with the bistoury, to the great injury of the patient. The chronic and—in the early stage—painless course of encephaloid disease, its possessing not one but multiple eminences, and frequently the enlarged veins running over the surface, will indicate its true nature. Mistakes, when committed, have been generally due to confounding elasticity with fluctuation, but these are very different.

Adipose tumors.—These may be distinguished from acute abscess by the absence of any inflammatory history, by their being without œdema or induration, and by their having a doughy consistence and lobular form.

Hernia.—In differentiating abscess from hernia the following considerations will conduct us to a just conclusion. Hernias are confined to certain definite regions not common to abscesses. They often occur suddenly, after some unusual effort; their progress is from above downward; they recede in the recumbent, reappear in the erect, position; usually they are reducible, elastic, doughy, resonant when containing intestine, and impart a distinct impulse to the hand in coughing. I have frequently known cold abscess below Poupart's ligament confounded with femoral hernia; but the mistake is inexcusable. Psoas abscess when it finds its way to the thigh is always on the outside of the vessels; hernia is on the inside.

We have still one resort in cases of doubt, which generally gives a satisfactory solution of the problem, and that is the exploring needle (Fig. 44).

FIG. 44.



Exploring needle.

This delicate instrument is simply a fine needle containing a groove. It may be thrust with impunity into any growth, and will conduct away a portion of the contents, if such exist, whether pus, blood, serum, or air. It is one of the most important aids in diagnosis, and resolves many surgical difficulties like a charm.

Divisions of Suppuration.—Suppuration may be divided into *superficial*, *diffused*, and *circumscribed*.

SUPERFICIAL SUPPURATION.—In superficial suppuration the pus is poured out from a free surface, as the mucous membrane of the nose, urethra, vagina, etc. Examples of this are seen in catarrh, gonorrhœa, and leucorrhœa.

DIFFUSED SUPPURATION.—In diffused suppuration the pus, having no limiting barrier, travels in different directions, infiltrating or separating the parts in which it occurs, and often inflicting great structural damage, such as is frequently seen in erysipelas, after compound fractures, poisoned wounds, and severe contusions. The extremities, scalp, and abdominal parietes suffer most frequently. When the suppuration occurs beneath the occipito-frontal aponeurosis of the scalp, the periosteum is liable to be separated from the bone; and the same is true of other parts, in deep suppurations.

This variety is met with in both good and bad constitutions. It is certainly not always due to deficiency of fibrin, by which the interspaces of the cellular tissue are sealed up and an obstacle offered to the purulent diffusion, but often to a wide-spread inflammation of the connective tissue, or to its insufficiency in amount.

Both of these causes operate in those cases of the disease which follow compound fractures, where the suppuration extends between separate, or the fasciculi of individual, muscles, and where the connective component is sparse as compared with the subcutaneous layer.

Instead of being a disease, as has been alleged by some writers, peculiar to scrofulous and broken-down constitutions, it has, in my experience, most frequently occurred in patients of the very best organization. Erysipelas, which so often gives rise to this kind of suppuration, is a disease of the robust as well as of the weak. I have seen all the cellular tissue of the inferior extremity destroyed by diffuse suppuration from exposure, even in a man of exceptional vigor and strength of body. In those instances of the disease which follow the introduction of some poisonous substance into the body, as in dissecting or post-mortem wounds, it is reasonable to suppose that there is some alteration in the constitution of the blood.

Symptoms.—As seen in erysipelas and after surgical injuries, the local signs may attract at first but little notice, the earliest indication of mischief being the constitutional disturbance. The patient is suddenly seized with a chill or rigors, followed by heats and copious perspirations; the circulation becomes quickened, the pulse being small and frequent; there is thirst, loss of appetite, and restlessness, with general derangement of the renal, intestinal, and other secretions. If the disease is extensive, and accompanied by much structural injury, the general symptoms become more urgent and threatening. The tongue assumes a dry, red, shining appearance, sometimes with a streak of dark fur along the centre; the strength rapidly fails; delirium sets in; the face becomes sallow and pinched; and the patient dies from constitutional irritation and blood-poisoning.

The local symptoms are somewhat peculiar, as contrasted with other forms of suppuration. The color is a dark, dusky red; the swelling not defined, nor very prominent, but diffused; the skin œdematous, from effusion of serum, especially when the pus is deeply situated, as under a resisting fascia; the pain extends over a considerable surface, instead of being concentrated, and sometimes is felt at a point remote from the disease. When the pus is confined in the profound parts of the neck, from pressure upon the brachial plexus of nerves, the pain or numbness may be experienced in the arm or hand; when in the buttock, the pain may be in the leg below, along the course of the sciatic nerve and its branches; when the parts are palpated, or pressed alternately between the hands, provided there is little resistance of tissues, a sound may be elicited similar to that of water in a half-filled rubber bag or bladder; the parts have lost their elasticity and firmness, and are soft and unresisting.

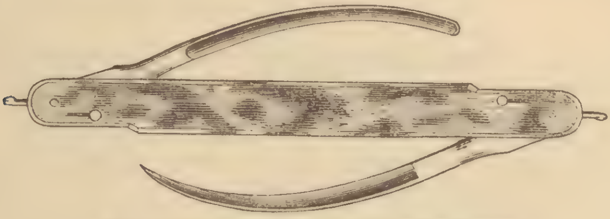
Diffuse suppuration, when not early recognized and promptly treated, is attended with the greatest danger to both limb and life. It is not the local damage done that renders our prognosis grave,—although that of itself is serious,—but it is the transudation and tissue-sewage which spoil the blood, rendering it unfit for the demands of the organs, and developing the typhoid symptoms which so rapidly supervene.

Treatment.—The treatment of diffuse suppuration should be decisive. The surgeon, in all cases where the disease is likely to occur, should make frequent and critical examinations. In phlegmonous erysipelas, it may be forestalled by free incisions into the part, unloading the subcutaneous cellular tissue of its transudation and the engorged vessels of their blood. In regions where important structures are crowded together, such as the neck, and when the pus is below the deep cervical fascia and may open into the œsophagus or cavity of the chest, we should not wait for pointing, but, selecting a place where there is some feeling of fluctuation, however obscure, should make an opening sufficiently free for the escape of the purulent accumulation.

It is not always safe to open such by a thrust, as in an ordinary abscess, yet to be described. A thoughtless or ignorant plunge of the bistoury may open large vessels, giving rise to dangerous hemorrhage. A safer method is

to incise the skin and divide the different strata of tissues upon a director until the pus is reached; or to make a puncture sufficiently deep to penetrate the deep fascia, and then introduce a director, breaking up the obstructing tissues until the matter makes its appearance, when, if necessary, a blunt-pointed bistoury (Fig. 45) may take the place of the director, and the wound be enlarged.

FIG. 45.



Blunt- and sharp-pointed bistoury for opening abscesses.

To prevent the opening from closing prematurely, before the disease is removed, a small tent of old linen should be twisted into a conical form (Fig. 46) and inserted into the opening by a rotatory movement effected between the thumb and the index-finger. This can be removed from time to time, say every six or twelve hours, until the orifice becomes indisposed to close up, when its use may be discontinued.

FIG. 46.

Conical tent.

When diffuse suppuration takes place in the extremities or other parts of the body, the opening or openings should be made at dependent points, so as to drain away the pus by gravitation. To prevent extension of the purulent matter, and to restore the displaced parts, pressure, whenever feasible, should be applied. For these purposes we can resort to the roller, compresses, or adhesive plaster.

The pus from this kind of suppuration is not healthy. It has little consistency, is mixed with blood and shreds of necrosed tissues, and excoriates the parts over which it flows. The odor is often offensive, especially when the pus comes from the vicinity of the rectum, in which case it is so impregnated with gases from the bowel as to be almost intolerable. Hence the importance of disinfecting and deodorizing the sinuous tracks of the disease and imparting to them a healthy action by injections. For this purpose we may use any of the following, two or three times in the twenty-four hours: permanganate of potash, one grain to the ounce of water; carbolic acid and water (one part of the acid to thirty parts of water); bromo-chloralum (one part to eight or ten of water); salicylic acid (one part of the acid, three parts of phosphate of sodium, and forty parts of water); phénol sodique, one drachm to six ounces of water.

When the suppuration, though not profuse, continues to linger, and the parts fail to unite, much advantage will be derived by injecting daily a weak solution of the sulphate of copper, three grains to the ounce of water. This will impart a healthy stimulus to the vessels. Dilute alcohol, one part to six or eight parts of water, will be found of great value in similar circumstances. Old linen, moistened with alcohol or equal parts of alcohol and warm water, makes the best external dressing. The great object, be it remembered, is to allow no accumulations in and no crevices or spaces between the components of the affected district. The frequency of dressing must be determined altogether by these indications; I am satisfied that the error is generally in too little rather than in too much dressing.

The constitutional treatment must not be overlooked. Pain and restlessness must be allayed by opiates, the strength sustained by tonics, such as quinine, tincture of the chloride of iron, and a nutritious diet, consisting of milk, animal soups, and stimulants; attention should be given to secure thorough

ventilation and sunlight, that the air of the apartment may be pure and fresh.

Circumscribed Suppuration.—When pus is surrounded or circumscribed by a limiting wall, it constitutes an *abscess*, a term derived from the Latin *abs* (from) and *cedo, cessum* (to go). The wall may be a natural one, as the pleura or the synovial membrane of a joint, or a preternatural one, the work of inflammatory transudation and organization.

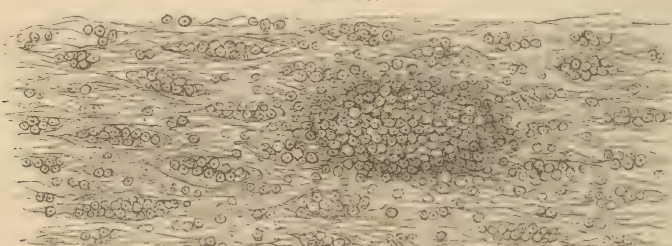
Abscesses may be divided into *acute*, *chronic*, and *disseminated*. Mr. Paget has described a form which he terms *residual*.

Acute Abscess—Phlegmonous Abscess.—Acute abscess is frequently met with in persons of a good constitution, and it passes rapidly through the various stages.

Symptoms.—It is ushered in by the phenomena of inflammation well pronounced, namely, pain, heat, redness, and swelling, together with more or less fever. The pain is acute, burning, throbbing, and when the part is pendent, every contraction of the left ventricle gives a pulsatile throb and tension often amounting to agony; the heat can be appreciated by the hand. The swelling is at first hard, which corresponds to the stage of vascular engorgement and exudation, but as the disease advances becomes acuminate and softer at the middle. Coincident with softening, which marks the stage of pus-formation, rigors set in, followed by hot skin and sweating. As the softening progresses, the color of the surface changes from red to a purplish, and finally, as the pus nears the surface, to a yellow hue, the skin becoming glossy and so attenuated that the pus may be seen beneath. The pain and constitutional symptoms now subside, and when the part is examined after the usual manner *fluctuation* is discovered.

Pathology.—In the formation of an abscess, the part is so infiltrated with liquor sanguinis and leucocytes as to fill up the meshes of the connective tissue and form a hard tumor. After a time many of these leucocytes, in virtue of their locomotive power and the intrusion of others streaming in from all sides, are pressed towards a central point or focus of the swelling (Fig. 47). The

Fig. 47.

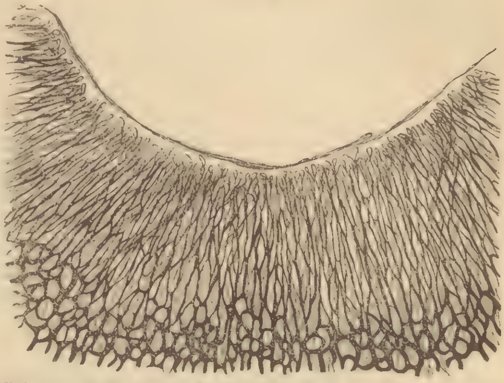


Infiltration in the formation of an abscess.—From Billroth.

result of such overcrowding is to compress the vessels, lymphatics, and connective-tissue fibres to a degree sufficient to arrest their nutrition. The consequence is that they become necrosed and melt down. Many of the connective-tissue corpuscles, thus liberated, or passing from the stable to the mobile state, together with the associated fat and other tissue débris, break up, pass into a fluid state, and become mingled with the other cell organisms and transudation (Fig. 48), so that softening or fluctuation replaces the induration at this central point, and in common language it is said that "matter has formed" or the disease has resulted in an abscess. At the circumference of this abscess there is a wall of living tissue which serves to circumscribe or partition it from the surrounding parts. It is this wall which distinguishes the circumscribed from the diffuse abscess, and which serves to imprison that which otherwise would disorganize the adjacent structures by infiltration or poison the blood by its absorption. This limiting wall is formed by a fibrinous

deposit intermingled with cells, projecting into which are loops of blood-vessels, so that when the pus is evacuated there is left a central cavity, corresponding to the necrosed parenchyma, surrounded on all sides by the wall just described.

Fig. 48.



Injection of the vessels in the walls of an abscess; outgrowths from those near its circumference.

Now, while it is common to speak of this wall as a barrier against purulent extension, an office which it doubtless does perform, we must not lose sight of the fact that it is true granulation-tissue. Billroth has well remarked that an abscess is only a hollow ulcer. This granulation-tissue does not differ from that which forms in the parenchyma of a part contiguous to a separating slough, or just within the line of an ulceration by which the dead is separated from living tissue; or from that which is seen filling up the chasm of an open wound or ordinary ulcer. In fine, it is the material for repairing the destruction made by the abscess.

Treatment.—As all abscesses are a sequence of inflammation, it is possible to prevent their formation by arresting the progress of the latter, or, in other words, by inducing resolution. This is clearly the first indication. The second proceeds on failure to effect the first, and consists in favoring the maturation of the abscess as rapidly as possible, or, what is its equivalent, provoking an abundant transudation. The third consists in evacuating the pus accumulations; and the fourth, in securing the restoration of the parts to their natural condition.

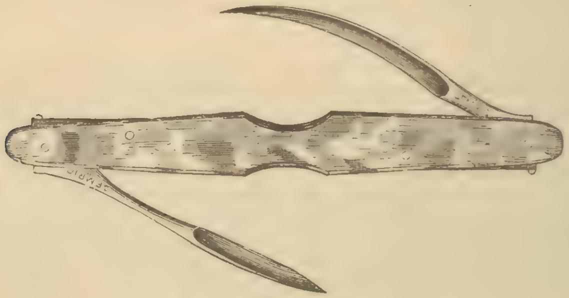
To effect the first indication, that of resolution, the case must be taken in hand at its incipiency. Most potent of all resources for this purpose is the abstraction of blood. When the disease is in the subcutaneous cellular tissue, this may be accomplished by leeches, cups, scarification, or incisions. How often do we see an attack of acute tonsillitis or conjunctivitis aborted by the timely use of leeches or free scarifications! If the patient is of a strong, full habit of body, general blood-letting will be indicated, provided the organ attacked is an important one. By such a measure a pneumonia may be arrested short of suppuration, the vessels of the lung being unloaded, and the vascular tension diminished. Any advantage thus gained must be followed up and maintained by the sedative influence of cold lotions, such as lead-water and laudanum. Cloths saturated with the liquid should be laid over and beyond the affected parts, and frequently renewed,—not covered with oiled silk, but exposed, so as to intensify their action by evaporation. Should the swelling continue to linger, notwithstanding that the active inflammatory symptoms have disappeared, a blister directly over the diseased locality will frequently, after the escape of serum, rapidly secure its removal. When cold gives rise to increased and continued pain, it should be exchanged for warmth, the degree to be determined by the sensations of the patient. Even when suppuration has taken place to a limited extent, we should not despair of being able to effect its dispersion or absorption. Moderate warmth, conjoined with pressure, will facilitate this desirable termination: cloths wet with warm water and laudanum, and retained by the turns of a roller firmly applied, constitute the best mode of using these measures.

When the above means fail to secure resolution or absorption of the matter, and suppuration goes forward, then we should proceed at once to favor the process, or ripen the abscess as rapidly as possible. Hot poultices of

bread and water, or flaxseed-meal, laid over the part and covered with oiled silk, and renewed every six or eight hours, constitute the best applications for this purpose. The heat and moisture soften the skin and invite a free transudation. The abscess, by disintegrating the connective tissue, advances forward or points; the skin desquamates and sloughs, becoming so attenuated that at last it is no longer able to withstand the pressure of the pus, and gives way, allowing the matter to escape. This is nature's method of opening an abscess. It is not usual, however, to wait for the spontaneous discharge of the accumulation: the surgeon interferes and makes an outlet by artificial means. The time when such intervention is proper will be determined by the locality of the disease. In abscesses of the ischio-rectal fossæ, an outlet should be made early, before pointing, otherwise the intestine may be perforated and a fistula established. Early interposition is also necessary in such as are termed retro-pharyngeal. Abscess of the tonsil should be opened early, and never allowed to break spontaneously. I have seen a young man, a medical student, lose his life by refusing obedience to this maxim. The abscess burst posteriorly, poured a torrent of pus into his trachea, and before assistance could be rendered he was dead.

Without specifying particular cases demanding prompt interference, I will say that whenever an abscess is accompanied with great suffering from tension, or is likely to produce serious structural damage, early interference is proper. Mr. Liston's case will serve to enforce this doctrine. An abscess in the neck had become adherent to the carotid, into which, from delay, it finally ulcerated, and when opened the patient lost his life from hemorrhage. When no urgency exists for an early evacuation of the matter it is usual and proper to wait until the collection is mature, as indicated by distinct fluctuation and pointing. The opening should be made with a sharp-pointed straight or curved bistoury (Fig. 49). The finger and thumb of one hand being pressed

Fig. 49.



Sharp-pointed bistoury.

on opposite sides of the swelling, so as to make the parts tense, the surgeon with the other, holding the bistoury in the manner of a writing-pen perpendicularly to the abscess, thrusts the point of the blade into the most prominent portion, carrying it onward until all resistance ceases, or until the pus is seen welling up on the sides of the blade, when the instrument should be changed to the oblique position, so as to make the point more superficial, and the opening enlarged to the required extent from within outwards as the knife is withdrawn, the object being to give a free and unembarrassed escape to the purulent matter. I prefer a good-sized opening. If the patient be timid, or afraid of pain, the part may be first rendered insensible by the ether-spray, or by ice.

In opening abscesses deeply situated in regions where there are important blood-vessels, there must be no reckless plunges of the knife. The rule laid down when treating of diffuse suppuration is equally applicable here,—namely, to incise the superficial layers below the skin on the director, opening the deep fascia, and breaking up the wall of the abscess with its extremity.

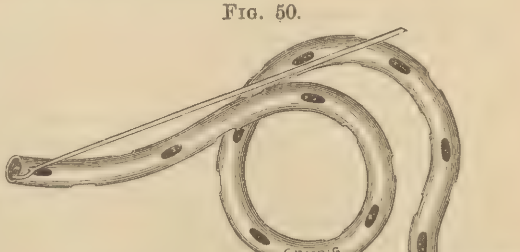
If the opening be sufficiently large, the pus will escape, usually mixed with some blood, and the flow, after a little while, may be assisted by gentle pressure, never carried, however, to the extent of giving severe pain. If the abscess is large, the opening should be prevented from healing by introducing a small tent, until the cavity is sufficiently contracted. For the first two or three days after emptying the abscess the best dressing is a light flaxseed-meal poultice, after which a piece of linen, wet with laudanum and water, covered with oiled silk, and made fast by a roller, forms the most appropriate application. Benzoated oxide of zinc ointment, simple cerate, or lead cerate answers also a very good purpose. The pressure is necessary to bring into close apposition the sides of the cavity vacated by the pus and secure its obliteration by the union of the granulations which form its periphery.

The induration which forms the circumference of the central depot of pus disappears in three ways. A part is discharged through the opening, as pus; a part undergoes a retrograde metamorphosis, and is disposed of by absorption; whilst the remaining portion is developed into connective tissue, and becomes a stable component of the surrounding structure, the evidence of which is seen in the compact nature of the cellular tissue which continues for some time about the seat of an abscess.

Occasionally there are complications following an abscess which require notice. It may refuse to heal from several causes. 1. From an imperfect apposition of its surfaces: this must be obviated by accurately adjusted pressure by means of graduated compresses and rollers. 2. From an indolent state of the granulation-tissue: this may be corrected by stimulating injections, such as the sulphate of copper, three grains to the ounce of water; nitrate of silver, two grains to the ounce of distilled water; or dilute carbolic acid, followed by compression. 3. From imperfect drainage, in consequence of which a certain amount of pus remains: this will require another opening, made at a dependent point. 4. From crevices in the limiting wall, allowing the pus to diffuse itself through the contiguous parts: here the difficulty should be met by counter-openings, injections, and compression applied, not only over the diseased district, but also beyond its limits. 5. From hemorrhage, which, if not controlled by pressure, will require that the abscess be freely laid open and all coagula removed. Should this not answer, then the bleeding vessel must be sought for, and secured by ligature. 6. From constitutional weakness: this will be best combated by the use of tonics, such as quinine, tincture of the chloride of iron, nourishing diet, and fresh air.

When the drainage is imperfect, and the case proves obstinate, we may resort to the drainage-tube of Chassaignac. This, which is a piece of gum tubing having numerous openings cut in its sides, should be thrust into the cavity by a probe or a pair of forceps having blunt-pointed blades, or by a notched probe (Fig. 50). As the discharge diminishes, the tube can be gradually withdrawn.

Fig. 50.



Notched probe applied to the drainage-tube preliminary to placing it in position.

Fistulous tracts may remain and complicate the healing. These are very prone to form when the abscess is in the perineum, axilla, or groin, parts that do not allow of entire quiet or rest. These are best treated by laying open, on a director, with a probe-pointed bistoury, the entire extent of the fistulous canal, and packing it with dry or oiled lint.

Chronic Abscess.—Chronic abscess appears in surgical writings under

various designations, as cold, scrofulous, and tuberculous abscess. There are objections to be urged against any of these names; but the word chronic is perhaps as well suited to individualize the disease as any other. A chronic abscess is one which is slow in its progress, and in a large proportion of cases owes its existence to a peculiar state of the constitution, a diathesis, or dyscrasia. It should not be forgotten, however, that between the acute and the chronic abscess there are many degrees, in consequence of which we fail, in numerous cases, to discover any sharp lines of distinction. In the more typical forms of the disease chronic abscess differs from the acute in the age and constitution of its subjects, as well as in its origin, progress, symptoms, anatomy, treatment, and results.

It generally occurs in the young and in those who have imbedded in their organization a scrofulous or tuberculous vice. It is symptomatic of disease of the joints, bones, and lymphatic glands. Such are those abscesses which form about the hip, knee, elbow, and other articulations, consequent upon strumous arthritis, those that make their appearance on the back and groin in disease of the spine, and those which form in the glands of the neck and axilla in scrofulosis. Abscesses of this kind which change their place, or rather which, in consequence of gravitation and fascial attachments, dissect their way to points remote from their origin, are called *congestive*. Such abscesses are those which originate about the lumbar vertebræ, and, following the psoas fascia, are conducted beneath Poupart's ligament to the thigh. The name should be discarded.

There are acquired conditions of the system, not peculiar to age, which predispose to chronic abscess generally confined to the subcutaneous tissue. These are seen after low fevers, or in the course of organic disease of the kidneys, in which the blood has been spoiled by the introduction, from without, of some pernicious material, or where the kidneys fail to eliminate certain compounds, which, by their presence in the circulation, work a similar mischief. It is no uncommon experience to see these abscesses follow typhoid fever during convalescence, or develop in the course of acute Bright's disease of the kidney. Whatever destroys the plasticity of the blood or defibrinates it would appear to favor this kind of suppuration. I have seen, in a patient who had at different times taken largely of alkaline remedies for disease of the bladder, numerous little painless knots of indurated tissue form at points where morphia had been inserted hypodermically, and which gradually ripened into abscesses, the pus of which was unhealthy and intermixed with a gummy or ropy fluid. Such abscesses when absorbed leave a depressed and white cicatrix. Professor Stillé relates to me the case of a man who, to obtain relief from a painful affection, had recourse successfully to the hypodermic use of morphia. Some time afterwards he was attacked with rheumatism, and for this he used alkalies freely. In a short time the places where the subcutaneous injections had been made, and which had hitherto remained entirely quiescent, began to swell, and abscesses formed.

Old inflammatory indurations, such as are seen about bones or articulations which have been the subjects of disease, often take on this form of suppuration. This corresponds in part to Mr. Paget's *residual* abscess, and is one of nature's methods of getting rid of the thickening.

Chronic abscess is slow in its development and progress. It is quite common to see such collections after months attain a considerable size, and then for a long time remain unchanged. I can recall cases which remained without opening for two years.

The symptoms of chronic abscess are peculiar. They are not at all demonstrative. The disease may arise so insidiously, and with so little inconvenience, that its presence will not even be suspected. It is no uncommon occurrence to meet with cases of lumbar abscess which have been treated for lumbago, the patient realizing nothing more than some uneasiness, stiffness, or slight pain in the back. When the swelling becomes visible it is not red or inflamed, but rather is blanched or pale; the sensibility is trifling; it

may be handled even rudely without pain; the temperature is not exalted,—whence the term "cold abscess" of the Germans. It has little tendency to pointing: the absence of acute inflammation and the great thickness of the sac are conditions which are unfavorable to this, and when such a result does occur it is preceded by a dark or brown rather than a scarlet color. There is little if any œdema, and the integument, which before was movable over the sac, becomes adherent to its surface. Chronic abscesses are remarkable, again, for the enormous bulk which they frequently attain, or, what is equivalent to this, the amount of pus which they contain without becoming acuminated. I have removed fifteen pints from such an abscess.

The contents of chronic abscesses are peculiar. The matter may be thin, whey-like, but generally is more consistent, of a yellowish color, containing many cheesy-looking masses and often shreds of necrosed tissue. Unless in close proximity to the bowel, or where there is bone disease or considerable structural débris, there is not much odor. When the pus is subjected to a microscopical examination it will be found much changed, its corpuscles blighted and broken up by chemical and other agencies, an abundance of granular or molecular particles floating in the liquid, together with numerous crystals of cholesterin, the product of fat metamorphosis.

The encapsulating wall of a cold abscess differs only in thickness, strength, and development from that present in the acute form of the disease. Much of the inflammatory transudation is organized into connective tissue, so that this wall becomes a fibrous sac sometimes of great thickness. It is permeated by blood-vessels, and by the older writers was supposed to be endowed with the power of secreting pus,—whence the origin of the name "pyogenic" membrane. Its formation is a very slow process, for two reasons, viz., the chronic form of inflammation present and the small amount of connective tissue. It often utilizes pre-existing structures, fashioning them into a wall or sac, as may be seen in the iliac and psoas abscess, in which the strong sheaths of these muscles constitute a part of the inclosing membrane. The exterior of this wall or sac is irregular, bristling with prolongations which interpenetrate the surrounding parts, while the interior has a villous or granular appearance, the eminences consisting of loops of blood-vessels buried in transudation corpuscles. These vessels are the source of the leucocytes which form the pus of the abscess, the connective tissue, at least in several localities, playing a very subordinate part in its production. The capacity of these abscesses and the distance of their contents from the surrounding vital wall may account in part for the peculiar character of the pus.

A practical point of some importance connected with the sac of a cold abscess, is the difficulty in some instances of recognizing fluctuation: this is due to its great thickness, and the difficulty is increased if there be only a small amount of pus present.

Occasionally the wall of a chronic abscess is constricted at one or more points, giving rise to a variety called multilocular, the constrictions between the loculi being determined by unyielding connections of overlying fasciæ or other structures.

Constitutional Symptoms.—These, like the local ones, at first attract but little notice. The surgeon will, however, detect a steady loss of flesh, increased anæmia, a red spot on the cheek, an unnatural bluish-white state of the sclerotic coat of the eye, diminished strength, a frequent pulse, and towards evening a warm, dry condition of the skin, with burning palms of the hands and soles of the feet, succeeded by perspiration and sometimes diarrhœa. These symptoms become greatly intensified when the abscess is opened. The diagnosis of chronic abscess has been treated of under the head of suppuration in general.

Prognosis.—To forecast the future of a case of chronic abscess is not always an easy task. The considerations which are to guide the surgeon in forming an opinion as to the probable issue of a given case are the age and constitution of the patient, the location and size of the accumulation, and the

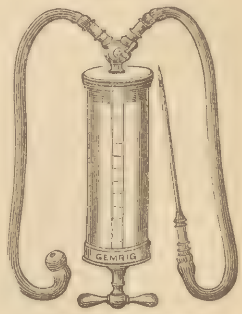
structure involved. The youth possesses a greater capacity of vital resistance than either the child or the old man. When of large size, the excessive draft upon the blood, and the constitutional disturbance incident to the opening of the abscess, are prone to wear out the patient through sheer exhaustion. Should the patient have been reduced by disease before the occurrence of the abscess, his chances of recovery are diminished, or should there be a latent predisposition to tuberculosis it may be rendered active by the suppuration and rapidly destroy life. The locations in which such abscesses are attended with special danger are within the pelvis, mediastinum, front of the cervical vertebræ, and neck; they may open into the bladder or trachea, or even form attachments to vessels, the opening of which by ulceration may be followed by fatal hemorrhage. The pressure of these abscesses is sometimes sufficient to obliterate blood-vessels, or cause a defensive thickening of their external coat. When the collection is produced by bone disease, age exercises an all-controlling influence in our prognosis. Inflammation of the spine, hip, and knee in children, which so generally gives rise to abscess, if early taken in hand admits of a large percentage of cures, whilst similar affections in the adult and aged tend to a fatal termination.

Abscesses of lymphatic glands, while they are generally very slow in their formation, are not usually dangerous, nor are those which form in the subcutaneous cellular tissue, provided they are not the sequence of bone disease.

Treatment.—The treatment of cold abscess differs from that of the acute form. In the latter the surgeon's object is to open at the earliest moment, or as soon as fluctuation is established; in the former, it is masterly inactivity, delay. In the latter, an incision resolves the difficulty; in the former, when the opening is established, whether by nature or by art, the trouble begins. Abscesses, however, of this nature, in the cellular tissue, having no association with bone disease, or occurring in lymphatic glands, we should not hesitate to open whenever the pus has formed. The contents of a cold abscess may be absorbed. This frequently occurs in disease of the spine. Another change occasionally takes place: the transudation and migration from the vessels of the encircling wall cease, it becomes a mere sac of connective tissue, and the contents are converted into a milk-like fluid with few, if any, corpuscular forms. Where the abscess opens spontaneously, or is incised, and the pus escapes, it sometimes happens—should there be sufficient vascularity of the sac—that the suppuration ceases or is greatly lessened, the interior eminences assume more the character of granulations, like those of an open ulcer, and as the walls contract they finally come together and unite, obliterating the cavity and leaving in its stead a mass of cicatricial tissue. Unfortunately, these are exceptional cases. As a rule, when an opening is made, and the pressure removed from the interior of the sac by the escape of the pus, it ceases to be the quiet, inoffensive swelling, which may have existed for months or years, and assumes the most formidable character; the suppuration begins with new vigor, the constitutional symptoms already detailed are rapidly developed, and the patient sinks under the exhausting process. The explanation given by many surgeons for so singular a behavior is the admission of air into the interior of the abscess; and hence the plan devised by Mr. Abernethy, of opening by what is called the valvular method,—that is, by selecting a dependent part of the swelling, drawing the skin to one side, and pushing a sharp-pointed bistoury into the sac. As long as the matter continues to flow and the sac contracts, no air will enter; and when it begins to cease, the skin is to be released, when the opening in the latter and that in the sac will no longer correspond. With the same end in view the *aspirator* is often employed. Several forms of this apparatus are in use. That of M. Dieulafoy consists of an exhausting glass syringe with two pieces of gum tubing, one of which fits on the nozzle at the lower end of the syringe and to which a trocar is attached, and the other to a side-nozzle, designed to convey away the aspirated fluid (Fig. 51). A valve in the first nozzle shuts off or opens communication with the abscess. The needle or trocar is to be plunged into the

abscess, the valve opened, and the piston drawn up; this has the effect of sucking into the syringe the purulent fluid; the stop-cock is next turned so as to close the communication with the trocar, and as the piston is forced down the matter passes through the side-nozzle and is conveyed through the attached tube into a vessel containing water. This instrument is an improvement on the American syringe known as that of Bowditch.

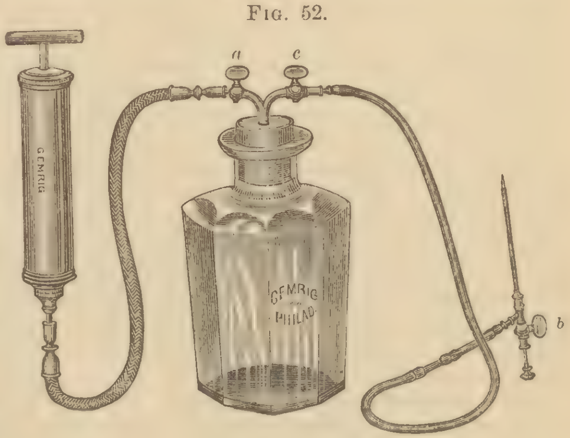
FIG. 51.



Dieulafoy's aspirator.

An apparatus in several respects superior to this is that of Potain (Fig. 52). It consists of a strong wide-mouthed glass jar with a closely-fitting gum stopper perforated by two tubes each having a stop-cock. To one of these is attached a rubber hose, the free end of which is constructed so as to articulate with a canula, through which runs a trocar; the other admits the nozzle of an air-pump. When used, the exhausting syringe is connected with its tube and the air removed from the bottle, leaving a vacuum, which is maintained by closing the cock *a*. The canula armed with a trocar is plunged into the abscess, after which the latter is withdrawn until its extremity is free from the stop-cock *b*, which is immediately turned to prevent the ingress of air. The stop-cock *c*, next to the bottle, being now opened, the matter rushes into the vacuum. One of the great advantages of this instrument is that it receives unpleasant odors as well as the pus.

FIG. 52.



Aspirator of Potain.

The question which is suggested by these beautiful mechanical contrivances is the following: Are all the symptoms which follow the opening of a chronic abscess to be referred exclusively to the admission of air and septic matters? I believe that they are not. I find them follow the use of aspirators as certainly as when other means are resorted to. And, while these are capital instruments, they are not essential,—a fact of some importance to physicians of limited means or living in out-of-the-way places where they cannot be readily obtained. A growth in the antrum is long repressed by the resistance which the walls of the superior maxillary offer; an ovarian cyst will often remain stationary for a long time when it attains a certain degree of tension; the increase of encephaloid disease when under deep fasciæ is much slower than when under less resisting structures. So with the abscess under consideration: the pressure against the strong surrounding sac and its vessels opposes transudation; but when it is opened, and that pressure removed, the vessels become distended by the blood determined to the part, the inflammation and ulceration assume a more active course, and the patient is destroyed by depletion, consequent upon the loss of the liquid albuminates and the corpuscles of the blood. The treatment, therefore, by almost common consent, is to decline any interference whatever with the abscess except on two conditions: first, when its extension is so disturbing the organs or parts in the midst of which it exists, that the injury to these is likely to be productive of as much evil to the system as that which would follow its

evacuation; and, second, when it is about to open spontaneously. When either of these conditions exists, it may be opened by aspirator, trocar, or bistoury; and since the air, bearing perhaps certain organisms which favor putrefactive changes, is doubtless one of the causes which excite increased suppuration, every precaution should be taken to exclude it or render it innocuous. With this object in view, the bistoury, when used, should be entered obliquely, and carried three-quarters of an inch between the integument and the sac before penetrating the latter. This gives us one method of forming the so-called valvular opening. Whether the germ theory of suppuration be correct or not, no harm can come of giving the patient the benefit of a doubt in using the antiseptic precautions of Mr. Lister, either by impregnating the air with the spray of water and carbolic acid (one part of acid to twenty parts of water), disseminated by an atomizer through the atmosphere about the abscess when it is opened, or by puncturing it under a veil of old linen saturated with carbolic acid and olive oil, in the proportion of one part of the former to fourteen of the latter. When the abscess is once opened, the contents should be allowed to flow out without much pressure, and if the orifice becomes obstructed by flakes of fibrin or shreds of dead connective tissue, a probe should be introduced, so as to dislodge them and maintain the continuity of the stream. It is sometimes advised to remove the contents of these abscesses by installments, allowing a few days to elapse between the operations, so that the system may not be too suddenly surprised, the openings in the intervals being closed by adhesive plaster. The advantages of this are, I think, imaginary; although no evil can result from the practice. I am disposed to believe that we have followed too blindly this venerable practice of abstaining from all interference with these abscesses, and that when feasible it might be better to open them as soon as discovered, by which a large pus-forming blood-vessel surface is prevented; but my experience in this plan is too limited to justify any positive statement.

However fruitless, in many instances, will be all attempts to obliterate these abscesses, yet, inasmuch as it is sometimes accomplished, it is proper that efforts should be made in that direction. As soon, therefore, as the contents have been removed, a drainage-tube should be inserted, in order that the pus may be conducted away as it is formed. This will favor the contraction of the sac, and, if its sides do not finally cicatrize, it may at least be converted into a narrow canal or sinus. Through this tube the cavity of the abscess may be occasionally treated and its action modified by injecting antiseptic fluids, such as carbolated water, solutions of boracic acid, permanganate of potash, or dilute tincture of iodine.

The constitutional treatment now becomes of the greatest moment. The strength must be sustained by a liberal diet, a reasonable amount of stimulants, and the use of tonics, such as quinine, tincture of the chloride of iron, infusion of gentian or quassia, with mineral acids, as the nitric, sulphuric, or nitro-muriatic.

Cod-liver oil constitutes a valuable remedy in such cases, especially when they are attended with loss of flesh. To relieve pain and procure rest, opium in some of its forms is indicated; and exercise in the open air, whenever the strength of the patient permits, must not be neglected.

ULCERATION.

Ulceration is a result of inflammation, both of the acute and of the chronic variety; most frequently of the latter. It is the destruction of a part by small installments; that is, molecular death instead of death in mass. In other words, ulceration is mortification on a minute scale.

Ulceration exists under two forms, the *open* and the *concealed*. The first or open form presents various degrees as to depth. It may only involve the epithelial layer of a tissue, as that of the skin or mucous membrane, when it is called an *abrasion* or *excoriation*, such as is seen in lachrymal obstruction,

where the tears run over the eyelid upon the cheek; or where the skin of the thigh and that of the abdomen come in contact at the fold of the groin; or when the vagina is subjected to acrid discharges from the uterus. When it involves the entire thickness of the skin, or mucous membrane, with or without the subjacent tissues, it is commonly called an *ulcer*.

The concealed variety, sometimes called ulcerative absorption, includes that inflammatory destruction of tissue which goes on in internal organs, as the lungs, liver, and kidneys, or in the bodies of the vertebræ. It does not necessarily communicate with the surface of the body; though this may occur as a secondary result by the formation of an abscess, leaving a sinus, or fistulous tract. While no tissue can be said to be entirely exempt from ulceration, save the hair and nails, there are certain ones which are much less disposed to become affected than others. Among these may be enumerated arteries, nerves, muscles, tendons; also the heart, brain, and salivary glands.

Causes.—These are *predisposing* and *exciting*. The predisposing causes, in general, are all such as impair the nutrition of a part. 1. The quality of the blood may give rise to ulceration. Instances of this are seen in those ulcerations which so often follow typhoid and scarlet fever; in those which succeed the introduction of certain poisonous matters into the circulation, causing, for example, smallpox and syphilis; and in those eruptions which so often appear upon the body of internes who have been long under the influence of a hospital atmosphere, or which develop on the persons of students who have been much occupied with the duties of the dissecting-room. Under the same head may be placed the multitudinous ulcerations found among the poor and indigent classes of a city population, who, from bad air, insufficient sunlight, and scanty or improper food, are under the most unfavorable hygienic conditions. In all such subjects the blood is so modified as to be unsuited to the demands of the tissues. 2. The amount of blood and the rate of circulation in a part are fruitful predisposing causes. Under this head are to be recognized two very opposite conditions,—too great, and too small, a supply. When a part is inundated with blood and transudation, as in acute inflammation, there is always danger of textural necrosis and consequent ulceration from capillary compression. Under such circumstances the destruction may be both rapid and extensive, as in phagedæna. An ordinary soft chancre, rubbed by the clothing, may suddenly become red, swollen, and painful, and in a few hours a large portion of the glans penis be destroyed. When the other extreme exists, namely, too small an amount of blood, the parts die from inanition,—are starved to death. Such a condition may result from defective motor-power in the heart, the blood not being driven to the tissues in sufficient quantity to supply their demands. It may also result from organic change in the walls of the vessels, as in atheroma, from embolic plugging of the vascular canals, from pressure on their walls by morbid growths, or even from the weight of the body, as is often witnessed in cases of bed-sores. The rate or activity of the circulation constitutes another important factor. When the blood lingers in a part,—either from excessive dilatation of the vessels, from venous obstruction, or simply from gravity,—loaded as it must be with the products of textural change, it ceases to answer the wants of the tissues, and becomes inimical to their life. It is in this way that structures which have been the subjects of repeated attacks of acute inflammation, or of chronic inflammation, are prone to ulceration. These facts explain the liability of varicose and paralyzed limbs to suffer in this manner. 3. Structural peculiarities predispose to ulceration. Thus, cicatrices, whether in the soft parts or in bone,—their vitality being low,—under certain conditions of the blood such as exist in scurvy and other diseases, readily take on ulceration.

Exciting Causes.—These comprise all those which are immediately concerned in provoking inflammation, among which may be enumerated wounds, bruises, and extremes of temperature; irritants of various kinds, as caustics and poisons, also those of smallpox, syphilis, and glanders.

The fact that local ulceration can be produced by the application of an

animal poison to the body, and that such an ulcer, when formed, is capable of reproducing itself by inoculation, has furnished the basis for a variety of this process, called *specific*, in contradistinction to what is called common ulceration.

Pathology.—Whether the ulceration consists in a simple abrasion, or involves the subjacent parts, we have the usual procession of inflammatory phenomena, namely, increased vascularity, manifested by unusual redness; infiltration of tissue by the transudation of serum, lymph, and leucocytes, giving rise to swelling; together with undue sensibility and warmth. When the action involves only the epithelium, the cells are rapidly pushed forward and ejected before they become flattened and horny, giving to the surface a raw appearance. When a greater depth of tissue is implicated, as in ordinary ulcers, the papillæ of the skin become enlarged by increase of their vascular loops, and by the liquid and cell infiltration of their connective tissue. The intercellular substance of the latter, as a consequence of the inflammation, undergoes softening, by which its corpuscles are liberated, and these, together with the migrated leucocytes, give rise to suppuration.

In this way the involved tissues, whatever they may be,—epithelial, connective, muscular, bone, or even morbid growths,—become dissolved, separate into particles, or disintegrate by molecules, leaving an open sore or ulcer. Just here we reach a point which displays the relation between ulceration and gangrene. They are identical in kind, differing only in the amount of tissue involved at one time. In both there is a slough: in ulceration it is only in particles, while in gangrene it consists of a mass of many particles. Mr. Paget, while admitting the general resemblance of the two processes, thinks there is a difference, stating in support of such distinction that a patient will go about with an ulcer, while a gangrene of the same dimensions would confine him to bed.

Around the margin of such a sore there will be some thickening, produced by inflammatory cell infiltration, which infiltration is concerned both in a defensive work for the surrounding parts, and in a constructive one, designed to repair the breach already made. It is the presence of the first which resists the extension of an ulcer.

When, however, the surrounding parts do give way, and the ulcer enlarges, it is not by absorption, or, if so, only in a very limited degree, but by molecular decay and ejectment. This decay and liquefaction are in part due, as has been shown by Mr. Goodsir,* to the new crowds of cells attracting to themselves the materials which should go to the nutrition of the affected tissues, the want of which hastens their dissolution.

The discharge which flows from an ulcerated surface is at first a thin, yellowish fluid, often containing a little blood, sometimes mixed with shreds of dead tissue, and called *ichor*. This is a kind of sewage formed from the blood, serum, and part of the débris of the decomposing structures, and exercises some solvent power over portions of the dead and dying fragments of tissue included within the boundaries of the ulcer. These by being macerated in the fluid have their liquefaction thereby favored. This ichor possesses irritating properties, and, when brought in contact with sound parts, excites inflammation. This is well exemplified in the red and excoriated condition of the skin surrounding an open cancer. That these discharges are in part made up from the structures affected is quite evident from the reactions which they display when subjected to appropriate tests. Thus, in the ulceration of bone the presence of the lime salts is readily detected by certain mineral acids.

What becomes of the tissues, the absence of which creates the chasm or loss of substance at the seat of ulceration? The answer to this question will, I think, be fairly stated when it is said that they disappear in two ways, —partly by absorption and partly by ejectment in the discharges. In the concealed variety, unless an opening occurs, it is altogether by absorption.

* Anatomical and Pathological Observations, page 15.

Examples of this are constantly seen in those ulcerations which are connected with disease of the spine, or in those which are excited by the continued stroke of an aneurism against the vertebræ: to such the term ulcerative absorption is quite appropriate. In these cases the order of removal is, first, the liquefaction of the organic part of the bone tissue, and next, such complete solution of the inorganic salts as to admit of their passage into the lymphatic and venous trunks.

In the open ulceration the removal is not altogether by ejectment, although in the main it is so. It is the absorption of certain products of decomposed tissue, in this variety, which in some instances poisons the system and in other cases provokes inflammatory fever.

When ulceration is established in order to empty an abscess, the most direct course towards the surface is taken, unless opposed by density or resistance of tissue. The sensibility of a part in a state of ulceration varies very much, depending greatly upon the activity of the accompanying inflammation. Common laborers are seen every day attending to their occupations with extensive ulcerations on the limbs, without complaint or great inconvenience, while in others a small sore, one which is red, hot, swollen, and painful, with no small constitutional disorder, will confine them to the house. In the first the inflammation is chronic, in the second it is acute. When situated in localities where much motion exists, there is usually considerable pain present, as when over the olecranon process of the ulna or the patella, or over muscles like the hamstrings and gastrocnemii. Intestinal ulcerations often produce extensive destruction, even perforating the entire thickness of the bowel, as occasionally occurs in the glands of Peyer in typhoid fever, and yet the patient be entirely unconscious of pain. Not unfrequently the pain is paroxysmal, is described as boring or gnawing, and comes on in the evening, or when the patient gets warm in bed. These are characteristic of the ulceration of bone, either from syphilitic or other causes. Sometimes the sensibility takes the form of intense itching, especially where the ulceration is situated on the vulva, anus, scrotum, or inside of the thighs, and so intense may this be as almost to drive the unfortunate sufferer to the verge of insanity.

Location.—Scarcely any portion of the body can claim exemption from ulceration, especially if the cause be of a specific origin; but the lower extremity, particularly below the knee, is the part most commonly attacked by the disease. In this locality it is generally confined to a limited portion of the limb,—namely, above the malleoli or at the lower third of the subcutaneous part of the tibia. The election of this region is due to several causes, which will be noticed when treating of ulcers.

Age and Social Condition.—Common ulceration is a disease of middle and advanced life, and is met with most commonly among the poor and indigent, simply because in these we have too often a combination of conditions, such as exposure, defective diet, and indifference to hygienic measures, which favor inflammatory attacks. When the disease is met with in the young, it is due to specific causes, such as scrofula or inherited syphilis.

The Work of Repair.—After the inflammatory new formation in a part, and its consequent destruction, we have the molecular separation or detachment taking place in the form of a slough saturated with ichor. This slough, which gives to the ulcerated surface a grayish appearance, is finally dissolved or washed out in the discharges. The discharge or ichor, which was of a sanious character, gradually diminishes in quantity. A new transudation of cells and fibrinous lymph takes place into the surrounding living tissues; the ichor is replaced by a more consistent, yellowish discharge, which is pus; the circumference of the ulcerated part becomes a little tumid from inflammatory infiltration, which diminishes outwardly. (Fig. 53.) Into the midst of the new cell formation shoot myriads of vascular loops, projected from the contiguous vessels; each convolution of a vessel gathers about itself a colony of cells, and gives to the entire surface of the ulcer the appearance of

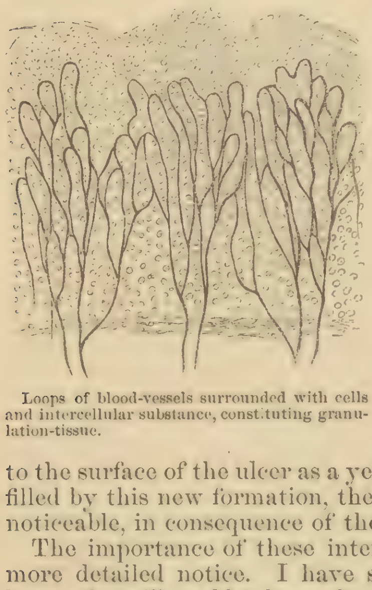
numerous red points closely massed together, each of which constitutes a *granulation*, and indicates the vascular districts of the natural tissue. A

Fig. 53.

a to *c* showing thickened edges of ulcer; *b*, the hypertrophied papillæ beneath the open surface.—From Billroth, after Forster.

granulation consists, therefore, of a loop of blood-vessels, a crowd of migrated leucocytes, and fibrinous lymph. (Fig. 54.) Out of this granulation-tissue the chasm is to be filled; without it repair is impossible.

Fig. 54.



Loops of blood-vessels surrounded with cells and intercellular substance, constituting granulation-tissue.

The edges of the ulcer soon lose their abrupt definition, and become rounded, or decline gradually towards the centre. The continued proliferation of this new formation finally fills the chasm, not by rising to the level of the surrounding skin, but by the descent of the latter from the removal of the infiltration and by contraction to the level of the granulations. The ulcer contracts by a shortening of its fibrous tissue and by the deep layer of cells becoming developed into rudimentary connective-tissue filaments united together by intermediate fibrinous material, while many of the more superficial cells are converted into pus-corpuscles, and are seen adhering to the surface of the ulcer as a yellowish fluid. As the ulcerated part becomes filled by this new formation, the pointed or granular appearance will be less noticeable, in consequence of the union of contiguous granulations.

The importance of these interesting bodies entitles them to a somewhat more detailed notice. I have said that granulations consist of convoluted loops of capillary blood-vessels, arteries, and veins, imbedded in the midst of round, nucleated, migrated leucocytes and fibrinous lymph. It is necessary for their production that the acute inflammation shall have subsided. They vary in size from that of a millet- to that of a mustard-seed. When healthy they present a beautiful florid hue, the walls of their vessels being exceedingly delicate, and often give way, pouring out blood, when rudely touched. They are not known to possess either nerves or lymphatics, although endowed with both sensation and absorption, as proven by the fact that the patient feels when they are touched, and that the application of morphia or arsenic will be followed by narcosis or poisoning. Their sensibility may be due to their relation with the nerves of the contiguous tissue, like that of the teeth or of the long, stiff hairs about the mouths of certain animals, and their power of absorption may be through the venous part of the capillary loop.

They are not confined to open surfaces, but may be seen in the interior of diseased joints or the cavities of inflamed bones. While they grow from any

structure, yet the subcutaneous connective tissue furnishes the most congenial soil for their rapid development. Like any other tissue, they are liable to become diseased. Sometimes they grow with a rank exuberance, rising above the skin and spreading over its surface like a mushroom, constituting the so-called "proud flesh." Sometimes they lose their characteristic color, become pale, flabby, œdematous, and devoid of sensibility. They may also shrivel up, assume a blue color, become exquisitely sensitive, bleed on the slightest touch, and in addition are frequently covered with dark crusts consisting of blood and serum. To the educated eye of the surgeon they not unfrequently convey important information of impending trouble, their shrunken, pale, and dry appearance often ushering in an attack of pyæmia or hospital gangrene.

Fig. 55.

Section through the border of a granulating ulcer, showing the cell-changes on its surface from the point of cicatrization inward: *a*, surface of ulcer covered with pus; *b*, below the pus-cells, the true granulation-tissue, consisting of cells and loops of vessels; *c*, deepest cells, assuming spindle forms on their way to connective tissue; *e*, epithelial formation, or cicatrization begun; *f*, cells beginning to take on epithelial forms; and *g*, cells in a condition preliminary to epithelial transformation.—From Rindfleisch.

Cicatrization.—When the skin and granulation-tissue attain the same level, the surface of the latter becomes smooth, glossy, and less granular by the union of contiguous granulations, the chasm contracts, the pus diminishes in quantity at the place of juncture between the skin and new formation, and at this point a delicate red line is seen, followed by a thin blue film, which gradually advances towards the centre; this is the formation of the epidermis, or new skin, and consists in the transformation of the round cells into flat ones. This constitutes the process of *cicatrization.* It begins at the circumference, and is doubtless determined by contact with the old skin, the influence of which is evident from the fact that the further removed from the latter the slower is the process of cicatrization. There is no evidence that cicatrization ever takes place in any other way. The supposition that islands or isolated patches of epidermis can form at irregular points over a granulating surface,

independent of the old skin, is not supported by any well-established cases. On the truth of this statement is founded the practice of skin-grafting.

The surface of an ulcer just commencing to cicatrize will, if examined from the centre to the circumference, be found to present well-marked distinctions. Farthest from the edges will be seen abundance of pus-cells; within these, and nearer the edge, others which are about to assume epithelial or flattened forms; still farther in, cells which are in an advanced stage of transition from round to flat or epithelial cells; and at the borders of the ulcer, epithelial cells fully developed. (See Fig. 55.)

While the cicatrization is going forward, the underlying granulations undergo important changes. Many of the cells disintegrate and disappear by absorption, while others become spindle-shaped. This change, with the simultaneous fibrillation of the intercellular or fibrogenous substance, forms connective tissue. When the process is complete the result is called a *cicatrix*. At first this is quite red, but as time advances it becomes paler, in consequence of the contraction of the adjacent connective tissue obliterating the blood-channels or leaving them as solid filaments, and at last, as its vascularity diminishes, it becomes white, presenting a striking contrast with the adjoining skin, so that the cicatrix or scar remains forever visible. Wonderful as the restoration is, the new tissue which replaces the lost never attains the perfection of the latter. It is dryer and more dense, does not possess hair, has no sudoriferous or sebaceous glands, and seems never to lose the tendency to contraction, so that frequently through this persistent property the most serious deformities are produced, such as are seen after burns or scalds, causing eversion of the eyelids and lips, or drawing the chin down upon the breast. The low vitality of a cicatrix renders it less capable of defending itself against either external injury or morbid conditions of the general system: hence a little undue pressure, a contusion, or an attack of disease in which the blood has been vitiated, will suffice to provoke its ulceration or to engraft upon it that singular condition known as keloid.

ULCERS.

After the foregoing observations on ulceration the subject of ulcers may be next considered.

What is an ulcer? It is a granulating surface following ulceration or mortification.

Classification.—Scarcely any two writers agree on this subject; and to attempt anything like a historical enumeration of the various divisions adopted, from the formidable ones of Sir Everard Home, Benjamin Bell, and Sir Astley Cooper to the simple one of Mr. Syme, would be as unprofitable as it would be laborious. The unnecessary multiplication of varieties, together with the ridiculous refinements which some authors have adopted, gives such gigantic proportions to the subject that students are apt to turn aside from the study of the subject in despair of ever being able to master the task.

I shall divide all ulcers into two classes,—*local* and *constitutional*. Under the head of local ulcers are included all those which depend for their existence on external or local causes, such as contusions, cuts, burns, scalds, varicose veins, dead bone, etc. Under the head of constitutional ulcers are classed all such as owe their beginning and continuance to a vice of the general system, a dyscrasia, such as exists in cancer, scrofula, syphilis, or variola, or those that arise from a cause that affects the proper distribution of nerve-force, as paralysis.

Common or Local Ulcers.—There are two varieties of common or local ulcers, namely, the *simple* and the *complicated*.

Simple Ulcer.—As it is only by an accurate knowledge of the characteristics of the simple sore or ulcer that we are able to appreciate those con-

ditions which constitute complications or deviations, it will be necessary to describe its peculiarities and appearance.

1. *Location.*—The simple ulcer may be situated on any part of the body, though generally it is seen upon the inferior extremity, and largely confined to the lower half of the anterior and outer portion of the leg. The reasons for this preference are obvious. This part is much exposed to injury, as well as to variations of temperature. Over the subcutaneous surface of the tibia there is little cellulo-adipose material, in consequence of which the vitality of the parts is endangered by slight contusions. In addition to these causes another may be stated as arising from the remote distance of the parts from the heart, by which the circulation through the veins of the leg, always much under the influence of gravity, is more or less embarrassed.

2. *Form.*—These ulcers may assume a variety of forms, depending somewhat on the manner in which the determining cause operates,—whether concentrated, like a blow, or diffused, like a scald; whether produced by a cut or a laceration: yet the prevailing tendency is to assume a round or oval form.

3. The *borders* are smooth, rounded, free from irregularities or indentations, and shelve off with a gentle declivity towards the ulcer. The skin for a short distance around is a trifle more consistent or firm, from inflammatory infiltration, and with a degree of redness slightly greater than the normal condition, but is without marked induration or unusual sensibility.

4. The *depth* depends somewhat on the amount of tissue destroyed; it is deceptive, being less than it appears to be.

5. The *granulations* are florid and acuminated, giving to the surface of the sore a granular appearance, possess a considerable degree of elasticity, do not bleed when gently touched, and never rise above the level of the surrounding skin.

4. The *discharges* consist of healthy pus, which is not in excess, and which, being neutral in its reaction, is bland and free from all irritating properties either to the granulations or to the skin.

In the development of such an ulcer there may be present acute inflammation, the parts being intensely injected with blood, hot, swollen, purple, œdematous, and exceedingly painful. When the ulcer is situated on the leg the entire limb may participate in the suffering. The constitution will sympathize with the local disturbance, as manifested by high febrile excitement, with headache, dry and hot skin, parched mouth, coated tongue, and loss of appetite, with disordered secretions. After the destruction has been effected and the slough ejected, these symptoms subside, and the ulcer puts on the appearances previously detailed.

Treatment.—When the structural change is simply epithelial giving rise to excoriation, bathing the parts with warm water and applying the benzoated oxide of zinc ointment, or dusting with a powder composed of equal parts of calomel and prepared chalk, will usually remove the disease. During the inflammatory stage, that preliminary to the formation of an ulcer, the treatment should be vigorously antiphlogistic; the object being to limit the destruction of tissue. The patient should be kept at rest in the recumbent position, and the part, when feasible, elevated, or placed on an inclined plane, or in a sling, so as to lessen the force of the circulation. Blood may be freely drawn by leeches or cups. I have never seen irritation from leech-bites when properly placed. They should be applied a little distance from the disease, so that the incisions may not add to the local irritation. After the abstraction of blood, refrigerant lotions of cold or cool water, or of lead-water and laudanum, should be employed, applied by saturating cloths with the liquid and renewing as often as they become dry. Irrigation, after the manner described in the treatment of acute inflammation, is a very efficient mode of applying cold. After the acute symptoms are past, some caution is requisite in the use of this agent. It may be continued too long, and so depress the vitality of the structures involved as to favor, rather than prevent, their

destruction. Anticipating the possibility of such a result, a moderate degree of warmth may be substituted by using lukewarm water, or by covering the dressing with a piece of oiled silk to prevent the evaporation which intensifies the cold. The bowels should be freely opened with a saline cathartic, preceded by three or four grains of calomel, after which the neutral mixture, conjoined with small doses of morphia, may be given every two or three hours. The diet should be restricted to the lightest articles, such as milk, arrow-root, barley-water, and broth. When the definition between the dying and living tissues is formed, and the former begins to soften down and liquefy, a warm flaxseed-meal, bread-and-water, or yeast poultice renewed every five or six hours will hasten the process of separation. Preliminary to the application of the poultices the parts should be disinfected by washing with the permanganate of potash or chlorinated soda. The diet, at this stage, should be generous, such as eggs, beef-essence, or even solid food, if the patient's stomach can properly dispose of such. This treatment is, of course, based on the existence of an unimpaired, vigorous constitution, and an active inflammatory condition. Cases will occur in which, from a feeble, broken-down state of health, a nutritious diet, stimulants, and tonics will be demanded from the beginning to the termination: it involves no very great amount of judgment to determine which will be the proper course to pursue.

When the preliminary work of destruction and separation has been accomplished, and that of construction or repair has begun, the surgeon has little to do. The ulcer must never be rubbed with a sponge or rag; all redundant matters must be washed away by allowing a stream of warm water to fall upon its surface from the pores of a sponge. A piece of lint saturated with tepid water should be laid over the sore, and kept in place by the turns of a roller applied smoothly and with uniform pressure. The part must be maintained at perfect rest, for which purpose it is often necessary to use a splint in order to secure true immobility. Under such a course ulcers of the character described will usually speedily heal.

Complicated Ulcers.—From the typical ulcer described there are many shades of departure, but when carefully studied these deviations can be compressed into two divisions, viz., *ulcers with an exuberance* and *ulcers with a deficiency of new or reconstructive formation.*

Ulcers with Excess of New Formation.—This complication may exist from the beginning of the sore, or may be subsequently engrafted upon it from local or constitutional influences. In such an ulcer the sensibility may be moderate or may be intensely acute; the surrounding parts, œdematous, red, or purple; the edges, swollen and indurated; the sides, perpendicular, irregular, or everted; the form, round or oval; and the depth, variable and uneven. The granulations are redundant, and the discharges profuse, thin, and frequently intermingled with blood. When the surrounding parts are red, swollen, and tender, the edges perpendicular, and the granulations either shrunken or turgid and of a dark-red color, bleeding when touched, or streaked over with little blood-clots and often associated with sanious discharges, we have what is called by many writers the *irritable* sore. These conditions are generally the result of an inflammatory invasion of the ulcer, though, when present in a very mild degree, they may be caused by hyperæmia alone. This variety is frequently met with in nervous females, particularly such as suffer from disturbances of the digestive apparatus, attended with flatulent and acid eructations.

In this complication there is an active cell proliferation both in the walls of the ulcer and in its granulations, but notwithstanding this the latter do not grow. Their dark-red color indicates obstruction to the veins from the inflammatory infiltration at the edges of the ulcer pressing upon their trunks, and hence the blood is too long delayed in the new tissues, which become asphyxiated from containing more carbonic acid than is consistent with construction or cell life.

When the granulations, rather than the borders, of the ulcer become surcharged with blood, and the transudation goes on with great activity, the new formation increases with marvelous rapidity, overtops the sides of the sore, and spreads over the surrounding parts even for inches. This is the so-called *fungous* ulcer. (Fig. 56.) I have seen it most commonly on the calf of the leg. In severe cases it is a formidable-looking growth, and I have known limbs with such an ulcer condemned to amputation, under the impression that the disease was malignant.

FIG. 56.

Fungous ulcer.

When the granulations are not only exuberant but pale and bathed in a thin serous discharge, we have the *œdematous* ulcer.

If the surrounding parts become suddenly of a dusky red color, hot and swollen, with darting or dull pains involving the entire leg, if the discharges change to a blood-stained serum, the ulcer enlarging by inflammatory destruction of its sides, and its granulations becoming necrosed, forming a gray, shreddy, ash-colored slough, like wet felt, and if accompanying these local conditions there is a quick, irritable pulse, with fever, headache, restlessness, thirst, and disordered secretions, we have the *sloughing* ulcer. (Fig. 57.) The proliferation of new formation in this variety is so active as to divert supply from the more stable constituents of the sore and consequently cause its death.

FIG. 57.

Sloughing ulcer.

While it is possible for such complications as have been enumerated to arise in a person of good constitution from local irritation, violence, or improper applications, among which may be mentioned friction by the clothing,—a very peculiar and injurious excitant,—sour poultices, and irritating caustics, yet these are exceptional examples. As a rule, the local characteristics are but expressions of the general state of health. Thus, the *irritable* ulcer is often produced by excesses in eating and drinking; the *fungous* and *œdematous* sore is determined by constitutional disturbances which are induced by an imperfect supply of good food, advancing years, lymphatic temperament, anæmia, and disorders of menstruation; while the *sloughing* variety may be due to contact with foul, irritating dressings, or to dissolute and uncleanly habits.

TREATMENT.—Preliminary to all remedies is rest, absolute rest, in the recumbent position, and with the limb in a fracture-box or suspended by an anterior splint, especially if the patient is difficult to control. Next in importance is a diligent and searching inquiry into the habits and constitutional state of the patient. Generally it will be found that the digestive apparatus is at fault; and in order to unload the bowels and establish a healthy condition of the secretions of the intestinal and accessory glands, there is nothing more efficacious than a purge of calomel and jalap, ten grains each; or, if a less energetic measure is indicated, eight or ten grains of blue mass may be sub-

stituted, followed, in an hour or two, by half an ounce of sulphate of soda or magnesia.

Should there be pain and restlessness, opiates must be administered, in combination with the neutral mixture or nitrous ether. One tablespoonful of neutral mixture or a teaspoonful of the sweet spirit of nitre with a sixteenth to a twelfth of a grain of morphia, every two or three hours, answers the best purpose. For four or five days the diet should be light, consisting, for the most part, of milk, animal broths, and farinaceous substances, after which it may be changed with advantage to one of a more solid kind. All highly-seasoned articles of food and stimulants must be interdicted. If the patient has been a habitual tippler, it will not be prudent to withdraw all stimulants, but the quantity should be limited to two or three glasses of wine daily. If whisky or brandy be preferred, it is best given with milk.

A person whose health has been seriously shattered by a life of excess, exposure, or want will require a sustaining treatment. The food should consist of beef-essence, milk, milk-punch, eggs, and broiled meats,—five or six grains of pepsin being administered with each meal to assist the digestion. Tonics will also be demanded. Six or eight grains of quinine should be taken in the course of the day, with or without iron, according to the state of the blood. Infusions of cinchona or of gentian, conjoined with the tincture of nux vomica or nitric acid, may from time to time be alternated with the quinine; and if there be emaciation and progressive loss of strength, the phosphorized cod-liver oil will prove very serviceable, provided it is tolerated by the stomach.

Local Treatment.—The limb should be placed in an elevated, easy position. If the parts are tender, red, and swollen, scarifications, or leeches if obtainable, should be applied a short distance from the sore, and the surface kept wet with a water-dressing, applied by irrigation, or by laying over it a piece of old linen or lint well saturated with tepid water and renewed as often as it becomes dry; or the method of Chapman may be adopted, which consists in taking pieces of lint two inches wide and sufficiently long to more than encircle the limb, which are to be wet with water and applied like adhesive plasters, beginning a short distance below and terminating some distance above the ulcer, each strip overlapping somewhat the preceding one. These strips are to be next covered with a piece of oiled silk, and a flannel roller applied. The roller I regard as an indispensable part of the dressing of an ulcer; but the utmost care should be observed in its use. It should include the foot, and be laid on smoothly and with uniform pressure. To neglect these points is to damage rather than benefit the case. When there is much discharge from the ulcer, the lint should be wet with carbolated or boracic acid water (one part of carbolic acid to forty parts of water, or five grains of boracic acid to one ounce of water). Used in this way it absorbs and renders the discharges harmless, and should be renewed every second day, or oftener if a sense of discomfort is experienced. Few ulcers of the irritable kind will resist the water treatment, with rest and the correction of such constitutional disorders as may be present. In a few days the temperature, color, sensibility, and consistence of the parts about the ulcer will abate, the granulations begin to assume a healthy color, and the work of repair commence.

In cases where the surface of the ulcer is obstinately irritable, not yielding to the water treatment, the application of a solution of chloral (twelve grains to the ounce of water) often gives decided relief. A solution of the nitrate of silver (twenty or thirty grains to the ounce of distilled water) brushed not only over its surface but also for some distance around, will exercise the happiest effect in diminishing the sensibility and converting it into a healthy sore.

Should there be severe pain of a neuralgic kind which can be referred with certainty to the proper nerve, the latter should be divided, as advised by Mr. Hilton.

When there is unusual proliferation of the granulation-tissue,—as in the fungoid ulcer,—or when it becomes œdematous, a condition ordinarily associated with excessive growth, the indication is to cut off the redundant blood-supply which determines this excess. To effect this there are two methods,—compression and excision. The first is adapted to all cases in which the new formation only slightly overtops the margins of the ulcer; and when conjoined with agents possessing slightly astringent and escharotic properties, nothing can be more satisfactory. In carrying into effect this plan of compression all adherent matters should be removed with a wash of permanganate of potash, a layer of pulverized loaf-sugar or exsiccated alum sprinkled over the granulations, and two or three strips of adhesive plaster drawn tightly across the ulcer, covering and extending a little beyond its surface. A piece of patent lint should next be placed over the plaster, and the usual roller applied. This dressing must be removed every two or three days and renewed as in the first instance, until the new tissue is reduced below the level of the skin. When thus brought within the proper limits, this dressing may be laid aside and one of lime-water substituted, the application of which consists in saturating a piece of patent lint with the liquid, placing it over and beyond the ulcer, covering it with a patch of oiled silk, and making all fast by a roller, firmly applied.

The second method—that by excision—is proper when the granulations are not only above the level of the skin but spread over its surface like a mushroom. For such growths, caustic potassa and the hot iron are recommended by some surgeons; but excision is simple and rapidly effective. The operation is the work of a few moments, and consists in paring the mass away to the proper level with a keen-edged scalpel. The bleeding, though profuse at first, will soon cease, after which the water-dressing should be applied.

When the granulations of an ulcer lose their vascularity and die, forming an ash-colored or gray mass, either with or without any marked alteration of the edges, it forms the sloughing ulcer already described. This must not be confounded with phagedænic destruction, a disease or morbid process altogether different, and which, except from causes of a specific nature, such as give rise to hospital gangrene or syphilis, is not seen in connection with ulcers.

To correct this complication, our remedies, in many cases, will have to be directed to the system at large as well as to the local condition. Any disorder of the digestive organs which can be discovered must be corrected by laxatives, the use of tonics, a nutritious diet, and stimulants.

In order to get rid of the necrosed tissue, and establish a free circulation in the ulcer by favoring the removal of the cell infiltration, a bread-and-water or flaxseed-meal poultice, moistened with a little lead-water and laudanum, should be applied, at each renewal the surface of the sore being cleansed with a wash consisting of one part of nitric acid to twenty parts of water. After two or three days' poulticing it may be necessary, in order to secure a further removal of the inflammatory infiltration, to paint the surrounding parts with Lugol's solution of iodine, to which may be added a little pulverized white sugar and gum acacia to render it less irritating.

Ulcers with Deficient New Formation.—These form a very large proportion of all the ulcers which the surgeon is called upon to treat. They abound in our almshouses and at our dispensaries, and are the bane of the laboring classes, both male and female. They are often multiple, and of many years' standing. It is no uncommon thing to meet with such sores which have been in existence for ten or fifteen, and in some cases twenty or more, years. They are sometimes termed *chronic* or *indolent*, and sometimes *callous* ulcers, and may have possessed their structural and vital peculiarities from the beginning, or may have begun as simple sores and been gradually transformed into the complicated ones. An ulcer of this kind is variable in form: it may be

round, oval, irregular, or may change from one shape to the other in the course of its eventful career. The same is true of its *depth*, although generally it is deeper than the simple form. The *edges* are sharply defined, abrupt; they may be inverted or everted. The *granulations* are generally small and pale, often absent, but may be redundant, flabby, and so saturated with a watery serum as to be translucent. The *discharges* are thin, occasionally consistent, blood-stained, and offensive. The *sensibility* is very dull. Having been the subject of both acute and chronic inflammation, the parts below and around the ulcer are thickened and indurated; the transudation, having gradually ripened into connective tissue, has by condensation formed a wall compressing the blood-vessels and preventing a free access of blood to, and its return from, the chasm to be repaired. (Fig. 58.) The venous channels necessarily becoming dilated have given to the surface of the surrounding parts a dark-red, blue, or deep-purple color. The skin is often covered by eczema, or it is smooth, glazed, and shining, and in aged persons whose legs are very thin it is frequently of a dark-brown or drab color. In the negro it assumes sometimes a piebald appearance, from the absorption, in patches, of the pigment-cells.

Fig. 58.

Indolent ulcer, or one with deficient proliferation or new formation.

These ulcers, when of long standing, are thought by some authors to perform a vicarious office for the system; and it is, perhaps, the influence of a popular notion of this kind which renders many persons thus affected disinclined to apply for surgical relief. I think there is no ground for such an opinion in the observation of those who have had the largest opportunities for forming a correct judgment. I am sure that, after a very large experience in the Philadelphia Hospital,—an institution which, from the character of its inmates, is peculiarly rich in this class of disease,—I can recall no instance which would give any support to such an opinion. Should, however, any symptoms of this kind arise, they are to be counteracted by keeping the bowels loose and restricting the diet.

The vicarious function imputed to ulcers, especially that of menstruation, I find has been very rarely met with. Blundell* instances the case of a girl in St. Thomas's Hospital who had a discharge from an ulcer on the hand which replaced a uterine discharge for three successive periods; another case is mentioned by Ashwell† of a nurse in Guy's Hospital, who menstruated regularly from a large ulcer on the thigh; also one by Dewees,‡ and one each by Whitehead,§ Mason,‖ Boring,¶ and Wiseman.** In Mason's case, a girl commenced menstruating at eight and continued until her eleventh year, when the discharge ceased for two years, during which time an abscess formed on the right cheek, suppurated in the centre, and bled from the edges; and blood would occasionally ooze from its surface even after it healed. The instance given by Boring was that of a colored woman who ceased menstruating at thirty-two, when blood flowed from an ulcer for a number of days

* Blundell, Principles and Practice of Obstetrics, by Lee, page 632.
† Ashwell, Diseases of Women, by Goddard, 1845, page 76.
‡ Dewees, Treatment of Diseases of Females, 1828.
§ Treatise on Abortion and Sterility.
‖ Mason, Edinburgh Medical Journal, 1866.
¶ New York Journal of Medicine, 1856, and Ranking's Abstract, vol. xxiii. page 258.
** Richard Wiseman, Chirurgeon to Charles II., 3d edition, London, 1719, page 311.

corresponding to her former menstrual period. Sometimes a bleb formed monthly alongside of the ulcer, which, on being punctured, yielded blood. Finally the ulcer became so large that amputation of the leg was performed, after which, at menstrual periods, blood-sacs or blebs would appear on the stump. Wiseman's case was that of a "gross, full-bodied maid, twenty-three years old, wanting her menstrual discharge; an abscess pushed out from the inside of the thigh, which resulted in a callous ulcer, discharging blood on periodical occasions."

I am not disposed to believe that the peculiarities of this ulcer, because it is found among the poor and laboring classes, depend upon constitutional causes, as the result of malnutrition, insufficient food, intemperance, etc. Those varieties which we have already considered as complicated by excessive proliferation are much oftener referable to such causes. On the contrary, the agencies which operate to prevent healing, and to continue the ulcer indefinitely, are local, such as exposure, carelessness, indifference to ordinary acts of cleanliness, and great muscular exertion in the erect position.

A common complication of ulcers is that arising from a varicose condition of the veins of the leg, or from the presence of dead bone, both of which may also form determining causes of ulcers. When the veins of the leg, as the radicles of the saphena interna or externa, become dilated, their trunks tortuous, and their valves disabled and useless, the embarrassment to the venous current cannot fail to influence the capillary circulation in a manner favorable to congestion of the tissues, and in this way maintain constantly one factor of inflammation, so that, on the slightest provocation by a cut or a bruise, the latter process is fully established, passing on to ulceration and the formation of a sore, which is termed the *varicose ulcer.*

It is unnecessary to discuss the propriety of admitting this ulcer into our surgical nosology. The opinion of Mr. Gay, that varicose veins are rather a result of than an antecedent to ulceration, meets no confirmation in my observation. I do not say that such a condition of a limb is the exciting cause of an ulcer, but that it is a very strong predisposing one. An injury which from its trifling nature would pass over without damage or evil consequences to a sound leg will, in one with imperfect veins, be followed by ulceration; and, further, unless this imperfection is provided for by suitable pressure, the resulting ulcer will prove exceedingly difficult to heal. Independent of direct injury, such an ulcer may form by the extreme tenuity or thinning of the wall of a vein in a varicose condition, until at last the inflammation of the overlying skin is established, followed by ulceration; or the vein may give way, attended with a profuse bleeding, and leave, after the vessel is closed, an ulcer in the contiguous parts. It is in these ulcerated varicose limbs that eczema is so often present.

When inflammation attacks the periosteum of a bone, or the bone itself, the disease may extend to the overlying soft parts and terminate in suppuration and an open sore. Such an ulcer depends for its existence upon the diseased bone.

Treatment.—The treatment of indolent ulcers, so often avoided, is not troublesome when their pathology is understood. The difficulty does not lie in the ulcer, but in the surrounding walls; it is not in the quality of the blood, but in the manner of its supply. The fact that the subjects of these ulcers are obliged, from the very nature of their pecuniary circumstances, to continue their employment, is a hindrance, but not an insuperable one, to the cure.

Save in exceptional cases, I do not believe in the constitutional origin of these ulcers; a glance at the sturdy Irish men and women who are so often the victims of this variety of disease will reveal enough to prove a sufficient refutation of such a doctrine: nevertheless the prudent surgeon will carefully inquire into the state of the general health, and correct any evils which may exist. I have lived long enough to learn that it is a waste of time and words, so far as ulcers are concerned, to dilate to this class of patients upon the

importance of a well-regulated diet and abstinence from intoxicating drinks. In most instances, in this country, their food, though plain, is as good, if not so delicately prepared, as that of the higher classes, and if they do indulge in stimulants the evil effects are measurably counteracted by the active and laborious nature of their callings; their habits are much less pernicious, indeed, than those of men who, after eating highly-seasoned food and drinking wines, spend the day in indolence and ease.

First, let the parts be thoroughly cleansed. Direct the patient, on his return from work in the evening, to place the leg in a bucket of warm bran-water—that is, water in which a small bag of wheat bran has been immersed for a short time—and allow it to soak for at least one hour; then, wiping it clean and dry, to envelop the parts with a towel wet in warm water and covered with oiled silk. This should be renewed in the morning before the patient goes to work. The same course should be pursued for two or three consecutive evenings. This water-bath and dressing will serve to macerate and soften the indurated tissues about the ulcer, by which a more perfect circulation is established: indeed, until this marginal induration is dispersed or melted away, all stimulating dressings to the surface of the sore are powerless for good. The next step involves the aid of an experienced hand. A piece of patent lint, doubled on itself and large enough to extend three inches beyond the limits of the ulcer, is soaked in warm water containing a very little alcohol, placed over the parts, and covered with oiled silk. A roller is next applied with the greatest precision to the foot and leg. This should be removed and reapplied every morning for four or five days, when it will usually be found that the hardness at the circumference and base of the ulcer has diminished, and that the granulations have begun to crop out. Now is the time for a more permanent dressing,—that is, one with adhesive strips, preliminary to the roller. This is commonly known as the method of Baynton,—a surgeon at Bristol,*—and consists in encircling the limb with adhesive strips two inches wide, commencing one inch below the ulcer, and terminating two or three inches above it. The plasters, according to this plan, were to be applied first over that part of the limb opposite the sore, and the ends made to cross over the latter two or three inches, each overlapping the preceding by one-third of its width, after which the foot and leg were to be bandaged with a calico roller. The dominant idea of Baynton was that of bringing the edges of the ulcer towards each other; yet that he had not overlooked the principle of equable pressure, as asserted by Mr. Critchett, is evident from the use of the roller firmly covering in the foot and leg. This plan of Baynton as improved by Scott,† of London, and afterwards by Mr. Critchett,‡ consists in applying adhesive strips first to the foot, leaving out the point of the heel, and thence extending them up the leg, over the ulcer, ending at, or above, the knee, and over all adjusting a roller bandage. As a rule, I do not think that American surgeons adhere rigidly to either of these plans. The one which I ordinarily employ, when the ulcer is near the malleoli, is as follows. Let the patient be seated on a chair, with the foot placed upon a stool of equal height; with a razor remove the hair from the limb, after which it should be elevated for a few minutes, in order to drain away all redundant blood. This done, the surgeon begins the application of adhesive strips. These should be from three-quarters of an inch to one inch in width, and long enough to extend three-fourths of the distance around the limb. The first strip is applied over the instep, terminating on the sole of the foot; overlapping this about a third of its width is placed a second; and so on successively until the ankle is reached. Placing the middle of a second series of strips behind the heel, their ends are brought forward and crossed, the first over the instep and ankle; from thence they are continued up the leg, ending three inches above the ulcer. Those over the sore should have minute per-

* Descriptive Account of Treating Old Ulcers of the Leg, by Thomas Baynton, 1792.
† John Scott, Treatise on Diseases of the Joints, 1828.
‡ Critchett on Ulcers.

forations, to allow the discharge to pass out. In applying these plasters to the ulcer, some place the middle of the strips across its surface, and then, drawing on each end, secure them simultaneously to the leg. It is much better, in order that the edges may receive firm pressure, to apply one end of the plaster at a point nearly opposite the sore, and bring the other over, making it fast on the other side. While the limb is still in the elevated or horizontal position, a roller bandage must be carefully applied from the toes to the knee. (Fig. 59.)

The roller is absolutely necessary to the completion of the dressing, as it not only aids in equalizing the support, but supplies additional pressure to the indurated tissues. Again, even at the risk of repetition, I would insist upon its smooth, even, and uniformly distributed support, otherwise it will come far short of its design. In two days it will be proper to take off the bandage, and, removing with a sponge the discharges which may have come through the plasters, again apply it as before. The adhesive strips should not be disturbed, if possible, for a week; though, if the leg becomes painful and the discharges profuse, they may be loosened earlier and renewed from the ankle upwards. Dr. Hunter, who has had much experience at our dispensaries in treating this class of patients, always applies a little oxide of zinc ointment over the margins of the ulcer before the strapping: it tends to prevent eczema by defending the skin.

FIG. 59.

Plaster strips applied, and the roller commencing to cover them in.

If the plan above described is carefully followed out in all its details, most ulcers of the class under consideration will be brought to successful cicatrization. When the ulcer is higher up, say five or six inches above the ankle, I have not found it necessary to begin the strapping at the foot, but two inches below the sore, terminating at the same distance above it. The roller will give the needful support to the other parts.

Occasionally an old ulcer will be met with which will prove invincible under this treatment, and it will be necessary to resort to other agencies preparatory to the strapping. The stronghold of its obstinate resistance will be found in the surrounding induration, the tissues being matted together by the products of chronic inflammation; and until this is removed it is impossible for the work of new formation to commence. If it is red and very sensitive, a few bold incisions, made down to the deep fascia, will prepare the way for the water-dressing and pressure. Some advise paring the indurated borders away with a bistoury. I once thought well of it, but I am now satisfied that the operation in most cases is unnecessary. If undue sensibility does not exist, a fly-blister covering the sore and parts beyond, as employed by Mr. Syme, will not only unload the overstrained vessels, but act as a salutary stimulus to the sore; after which pressure by adhesive strips and the roller will complete the work of cure. When great sensibility is associated with marginal infiltration and an arrest of repair, the application of a little iodoform will not only relieve suffering, but often excite a healthy action in the sore. An ulcer will sometimes refuse to heal in consequence of being over a tendon, as the tendo Achillis, or a muscle, as the sphincter ani, the movements of which disturb and defeat all efforts at repair. This can only be corrected either by absolute rest of the part, all movements being controlled by a splint, or, when this is not practicable, by the subcutaneous division of the tendon or muscle.

Ulcers are sometimes so extensive that cicatrization fails to close them in,

although the granulations may be healthy. The influence of the marginal cells is too feeble to reach across the chasm and keep up the cutification, and so the skinning reaches a certain point and then stops. This is often seen after extensive burns or destruction of the integuments by machinery. Under such circumstances modern surgery resorts to the process of *grafting*.

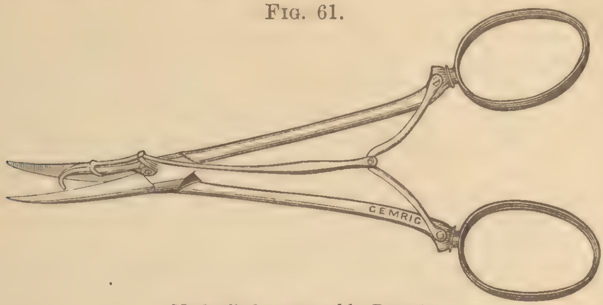
Skin-Grafting.—For the successful execution of this mode of treatment a healthy granulating surface is necessary, and if the ulcer be wanting in this particular it must, whatever its character, be brought into the required condition by proper treatment. The operation consists in the removal of small pieces of the true skin and their implantation upon the granulating surface. These grafts should be taken from the patient, not from another person. A neglect of this precaution may result in the communication of disease. It is not necessary that the pieces excised should extend deeper than the rete mucosum, and they may therefore be obtained without drawing blood, and with scarcely any pain. A portion of one of these pieces so obtained should be divided, upon a cork or the finger-nail, into smaller fragments, each about the size of a mustard-seed, which are to be laid on the sore (Fig. 60) about equidistant from its margin and from one another. It is not necessary that any depression be made among the granulations for their reception; they should be simply laid on the surface; nor is it a matter of much importance which side of the graft is uppermost,—just as in planting a seed it matters not how it is placed in the earth the root will strike down into the soil and the stem rise up into the air. To retain these grafts in place, pieces of adhesive plaster should be drawn over the ulcer, or, what is still better, the very delicate rubber tissue much used in the Scotch and English hospitals. A light compress of lint and a few turns of a roller complete the dressing. The patient must be kept in bed. On the third or fourth day the dressing should be removed, with great care and delicacy, in order that the grafts may not be uprooted or dragged away. After the surface of the ulcer has been cleansed by allowing a gentle stream of warm water to fall upon it from a sponge,—never by wiping its surface,—the dressing should be renewed as in the first instance. These little islands of skin will often appear dissolved, looking like a mere speck of apparently lifeless matter; but after a few days a bluish-white film is seen, and, below and around, puncta vasculosa, which are the evidences of vitality, and then begins the cell proliferation of the "graft." Not only does it extend, but the margins of the ulcer feel the power of its presence, and begin with new energy to stretch across the chasm of granulation-tissue, and join hands, as it were, with the little scattered islands of transplanted skin.

FIG. 60.

Skin-grafts placed upon a granulating surface.

There are several instruments which are in use for lifting the grafts. The simplest is a pair of delicate rat-toothed forceps and a pair of fine scissors

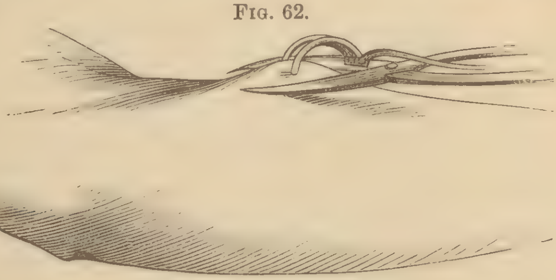
FIG. 61.



Macleod's forceps used by Bryant.

curved on the flat. Mr. Bryant, of Guy's Hospital, London, uses an instrument, the suggestion of Mr. Macleod, which is a combination of the forceps and scissors (Fig. 61), the application of which is seen in Fig. 62.

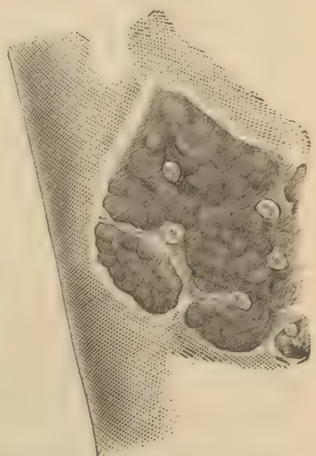
FIG. 62.



Method of using Macleod's forceps.

As far back as 1847, Professor Frank H. Hamilton, now of New York, planned an operation for closing a large ulcer by transferring a portion of integument to the centre of its surface, believing that it would form a nucleus for the production of new skin, and in 1854 he carried it into execution.* Although the portion so transferred had a pedicle, yet the method bore some resemblance to the present one of grafting, the integument being taken from a part distant from the ulcer, and not being designed to fill it up, but only to occupy a portion of the granulating surface. How much the operation of this distinguished surgeon may have had to do with attracting the attention of the *interne* of La Charité, M. Reverdin, to the subject, I know not, but in 1869 the latter presented to the Surgical Society of Paris† the history of a large ulcer which he had cured by excising a minute portion of skin and imbedding it in the surface of the sore. Shortly after this, attention was more generally attracted to the subject by the publication of the results of skin-grafting at St. George's Hospital by Mr. G. D. Pollock,‡ since which the operation has been largely practiced on both sides of the

FIG. 63.



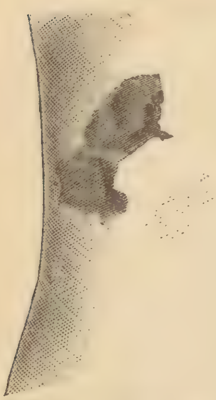
Prolongation and union of cicatricial tissue.

* New York Journal of Medicine, 1854. † Gazette des Hôpitaux, January, 1870.
‡ Transactions of the Clinical Society, London, 1871.

Atlantic, and with such success as to render it an established mode of treating certain kinds of ulcers.

It would appear that the grafts not only grow by virtue of the multiplication or proliferation of their own cells, but that they also stimulate, by some catalytic power, proliferation of the skin-cells which form the boundaries of the ulcer, so that the two run out cicatrizing promontories or arms towards each other, which finally coalesce and divide the sore into separate parts. (Fig. 63.) That these grafts lose none of their structural peculiarities by change of place appears from an experiment made by Bryant. He grafted into the ulcerated leg of a white man four fragments taken from the skin of a negro; they grew rapidly, closing up the gap with a black patch. (Fig. 64.)

Fig. 64.



Black skin in Bryant's case.

Epidermic grafting has been attempted by M. Marc Sée, of Paris, the late Mr. Poland, of Guy's Hospital, Professor Hodgen, of St. Louis, Guyon, and others, who think that the ulcers were improved by the presence of the epidermic cells. It consists in scraping the cuticle and placing it upon the ulcer. There is nothing, however, to show that any cicatrizing influence was exerted, or that the practice is worthy of imitation.

We are not yet prepared to determine how nearly the new skin formed by grafting approaches the old in the quality of enduring pressure, and in the property of contraction which belongs to other cicatrices. It does not possess either glands or hair, but it enjoys a sensibility quite as great as that of the other parts of the surface, and should be carefully protected for some time after the restoration of the ulcer.

When an ulcer is perpetuated by the presence of varicose veins, the great indication is to correct, as far as possible, the embarrassment of the venous circulation, on the presence of which depends the obstinate, chronic course of such sores. When the social condition of the patient admits of rest in the recumbent position it should be enforced, the limb being elevated; it will certainly facilitate the cure. But, as a very large proportion of such ulcers occur upon persons who cannot conveniently be laid aside from their accustomed occupations, it is a great satisfaction to know that rest is not essential to their healing. The sore is usually characterized by defective rather than excessive proliferation, and should, together with the surrounding parts, be subjected to the influence of a warm-water dressing or a flaxseed-meal poultice for a few nights, until it becomes cleansed of all tissue-débris. Through the day, also, the water-dressing, and a roller bandage applied when the limb is elevated, from the toes to the knee, answer every purpose. After this, strapping and the roller, renewed every two, four, or six days, according to the amount of discharges which soak the dressings, will meet the local indications. Constitutional treatment will often materially assist healing. Many cases of varicose enlargements of the leg-veins are due to mechanical causes within the abdomen, such as result from constipation or from hepatic enlargements pressing upon the large vessels of the body and of course affecting all their tributaries. A good purge, and afterwards keeping the bowels soluble with some saline administered from time to time, will, by removing these causes, greatly assist the surgeon in bringing to a successful issue the work of repair.

It is often true that relapses follow, but it is because the limb has been neglected. A well-adjusted roller bandage, or an elastic stocking, should be always worn for the support of the veins. In obstinate cases it is advised to destroy the offending veins by caustics, ligatures, or subcutaneous incision,—a practice which, so far as I have been able to observe, does not commend itself to my favor.

If, on exploration by means of a probe, dead bone is discovered communi-

cating, either directly or indirectly, with an ulcer, its removal will be necessary for a cure.

Eczema frequently affects the skin in the vicinity of ulcers; it is often caused by improper dressings. Nothing has proved so effectual in my experience in removing this troublesome condition as bathing the parts well with tar-water, and afterwards rubbing into the affected surface a powder consisting of equal parts of calomel and subnitrate of bismuth.

I have said nothing about ointments, astringents, balsams, vapors, and a formidable array of other remedies. These are fast disappearing from the dressing-case of the surgeon.

Ulcers from Internal or Constitutional Causes.

These causes may consist in structural changes affecting the function of organs, or from such widely-distributed influences as affect the fluids and solids of the body, producing what is termed a *dyscrasia*. Coming under the first head are the following:

Ulcers from Defective Innervation.—When, from paralysis, division, or the pressure of a morbid growth, the nerve-influence of a part is interrupted, that part loses a certain amount of self-protecting power: hence the bed-sores or ulcers which afflict bedridden paralytics, and which, from the consequent irritation and exhaustion, often hasten death.

To defective innervation, I think, belongs the *cold ulcer* of Mr. Paget, which appears at the ends of the fingers and toes, and occurs generally in females with faulty menstruation, defective digestion, and feeble pulse, the parts being slightly livid from imperfect circulation.

Treatment.—To prevent ulceration from defective innervation requires a strict attention to the state of the skin over those parts most exposed to pressure. For this purpose water- and air-beds, air- and hair-cushions, ring-pads, and felt soap-plasters are much employed. The frequent use of friction with alcohol or stimulating embrocations, like the camphorated soap liniment, by keeping up an active capillary circulation, is the most valuable of all local measures. When, in defiance of all precautions, such sores form, they should be managed according to the plan detailed for sloughing ulcers.

In the cold ulcer the remedies should be directed so as to correct the functional disturbances of the organs prominently involved. Eight or ten grains of blue mass should be administered, followed by a saline, after which preparations of iron, as the tincture of the chloride, come in with advantage. In addition, the patient should be allowed a generous diet, should live much in the open air, and should have the parts well rubbed with a weak solution of the bichloride of mercury or sulphate of copper.

The second variety of constitutional ulcers, or those from a *blood dyscrasia*, such as the strumous, syphilitic, scorbutic, cancerous, and lupoid, will be considered under the heads of these various diseases.

MORTIFICATION.

When all the phenomena which convey to the mind the idea of life in a part are absent, such as circulation, secretion, sensibility, and heat, we say the part is dead or mortified. When treating of this subject the older writers were in the habit of using the terms mortification, sphacelus, and gangrene. The signification which they attached to the first two was death, and to the last dying, or all those changes which are in operation preliminary to death. The retention of these terms is calculated to produce confusion and misapprehension in the mind of the student; they should be discarded from surgical nomenclature, and I shall retain only the term mortification, a derivative from two Latin words,—*mors*, "death," and *facio*, to "make." When mortification takes place in soft parts the dead portion is called a *slough;* when in bone, a *sequestrum*. Mortification in bone is expressed by the term *necrosis*.

No part of the body can claim exemption from this destructive process, except, perhaps, the heart, though some tissues are more prone to suffer than others. The greater the vascularity of a tissue or organ, the greater is the tendency to mortification, especially when they are subject to inflammation. Among those in which the disposition is greatest are the dermoid, connective, and adipose tissues; also the blood, mucous membranes, and muscles. Those which resist mortification longest are cartilage, tendons, bone, blood-vessels, large nerve-trunks, and brain-substance. It is not uncommon to see an artery still pervious to blood stretching across a chasm which has been formed by tissue-destruction. The final giving way of such trunks explains the fearful hemorrhages which occur in phthisis pulmonalis. Tendons remain long after the parts around them have been destroyed, and cartilages will retain their integrity when the bones with which they are associated are extensively disorganized. Glandular organs, except the lymphatic, are not often the subjects of mortification.

Causes.—A proper supply and a proper exchange of healthy blood are conditions necessary to the nutrition, and, consequently, the life, of any tissue or organ of the body. Whatever, therefore, prevents these predisposes to destruction or death. Many of these causes are in no way connected with the body, and are *external;* others lie within the organism, and are, therefore, *internal*.

External Causes.—These may be called *traumatic*, such as contusions, lacerations, pressure, caustics, burns, cold,—a class of injuries quite familiar to the hospital surgeon. They operate in two ways. When a heavy piece of casting or the wheel of a railroad-car crushes a limb, grinding it into a pulp, blood-vessels, nerves, and all the components of the part mortify. The blood-supply is immediately cut off, the molecular constituents of the tissues are so disturbed that the force of cohesion which operates between their particles, maintaining form and consistence, is lost, and they become the sport of those pure chemical mutations which are so active in decomposition. If a potent caustic, such as caustic potash or sulphuric acid, be applied to a part, in a few moments the latter is reduced to a blackened mass, blood and blood-vessels participating in the destruction. The same result follows the application of the actual cautery. In such examples as these the death is entirely independent of inflammation. Should, however, the vulnerating body operate with less intensity, so that a certain, though much diminished, amount of blood still reaches the damaged part, the sensibility of the tissue, though impaired, is not entirely lost. Under such a state of crippled circulation and innervation, inflammation will follow, by which the death of the part is insured. Here there are two factors at work to kill,—the injury which has impaired the vitality of the part, and the inflammation, which gives the finishing blow. In traumatic mortification death may be confined to a very circumscribed region, or to the area of contact, or it may extend far beyond, rapidly implicating an entire extremity. This is witnessed occasionally after railroad accidents or severe compound fractures, and is called "*spreading gangrene.*"

Internal Causes.—Under this head are to be classed all such as act by obstruction, both inflammatory and non-inflammatory.

Inflammatory obstruction.—This proves a fruitful source of mortification. When an intense inflammation, like that of erysipelas or carbuncle, befalls the skin or the subcutaneous tissues, the vessels are engorged with blood, the latter becomes stationary in the capillaries, and the parts are infiltrated with transudation, so that death follows by such a strangulation of the vessels as prevents the passage or renewal of the blood-supply. The terminal arteries, capillaries, and commencing veins are all implicated in such cases.

Arterial obstruction.—The obstruction of an artery may be brought about in several ways. When a ligature is placed about the principal vessel of a limb, like the femoral in cases of popliteal aneurism, the only hope for the parts below rests upon the collateral trunks. Should these fail to convey the blood through the anastomosing branches, mortification will follow.

Again, a tumor may so press upon an artery that the parts to which it is distributed will be deprived of blood and die.

Thrombosis.—By this is meant obstruction of a vessel or vessels by a coagulum of blood. When complete, and in the principal arterial trunk (Fig. 65), the mortification which follows is of the acute kind, and is apt to prove fatal. It is sometimes caused by inflammatory change in the wall of a vessel, producing a degree of roughening, or some little irregularity on its inner surface, which, like a thread stretched across the lumen of a vessel, serves to embarrass the free movement of the blood and finally form a clot. That such a coagulum may form altogether independent of inflammation is certainly true, even in persons of excellent health. Two such cases have come under my observation; one in the brachial artery, near the bend of the arm, in a shoemaker, in good health, and about thirty-five years old. The forearm mortified, and was subsequently amputated, the man recovering. The second case was that of a young, healthy female, who, while bending over the wash-tub, was seized with cramps in the leg, which soon became swollen: mortification of the entire limb followed, from the effects of which she rapidly sank and died. Obstruction of the femoral artery below the groin was readily diagnosed. These two cases would seem to favor the idea that the thrombi were determined by the sharp angle formed in the vessels from the peculiar nature of their occupations, the first by hammering on his lapstone and drawing the waxed-end, the other by bending over the wash-tub. A case of thrombus of the femoral artery, with a fatal termination, in a person believed to be free from any disease, has been reported by Dr. Walter F. Atlee, of this city. As these thrombi have both a parasitic and a vital connection with the vessels, they sometimes undergo softening, in consequence of which fragments are detached, which are called *emboli*, and which, when swept along in the blood-current, plug up the vessels and induce mortification. These peculiar formations are favored by rheumatic and feeble anæmic states of the system. They are most common in young females, and tend to a fatal termination.

FIG. 65.

Thrombus of the brachial artery extending into the radial.

Arterial obstruction is favored by a weak heart, a feeble circulation, endocarditis, narrowing of the lumen of the vessels, rigidity of their walls, anæmia, and atheroma.

Aneurismal dilatation is occasionally a cause of arterial obstruction. A short time since, a patient with popliteal aneurism, under my care, lost his leg by mortification in consequence of a fragment of coagulated blood from the sac being carried down into the vessels below.

Diseases of an exhausting kind.—Diseases which produce a profound alteration in the structure of the blood, as typhoid and exanthematous fevers, Bright's disease, and diphtheria, give rise to conditions favorable to arterial obstruction or embolism. I had a young man in the Pennsylvania Hospital with mortification of the foot and lower third of the leg, coming on during convalescence from typhoid fever. A line of separation formed, and the limb was removed with a successful result. A similar case I saw with a brother practitioner, in which, however, the patient foolishly declined amputation and died. Several cases I can recall of a less serious nature, in which the limb was not lost.

Blood-change, with a feeble heart.—This condition will favor mortification, entirely independent of either thrombi or emboli. Of this nature probably is the disease called noma, cancrum oris, or water-canker, to which the attention of the American profession was called long since by Coates and Jackson,* and which attacks the cheeks, lips, and gums of pale and weakly children. These

* Benjamin H. Coates, North American Medical and Surgical Journal; and Prof. S. Jackson, Medical Recorder, vol. xii.

causes are actively at work in those cases in which the disease appears at the outposts of the body, as the point of the nose, tips of the ears, and extreme ends of the fingers and toes. To this cause, in part at least, I refer the singularly symmetrical mortification of the limbs occasionally met with in France, which has been described by Raynaud.

Internal organs may suffer in this way. Numerous examples of mortification of the lung by arterial and venous obstructions are given by Ranctifuso,* Simonin,† Dumont, Palleir,‡ Fritz,§ M. Azain,|| Hayden,¶ and others. Cases of extensive plugging of the pulmonary arteries by emboli and thrombi without the occurrence of mortification are given by others, among whom may be named Paget** and Kirkes.†† When we consider that the bronchial and not the pulmonary arteries nourish the lungs, we can understand why there should be some doubt as to the part played by these clots in inducing mortification, and whether these obstructions may not be consequences rather than causes of the disease.

Venous obstruction.—This may be, in rare instances, a cause of mortification, by leaving no way of escape for the blood which has been carried into a part by the arteries. I can recall no case in which mortification could be referred to this condition. The numerous venous channels and their communications render it almost certain that if one trunk is compressed another will supplement the defect and so carry on the circulation. In strangulated hernia, where the knuckle of intestine is completely encircled by the constricting ring, rendering all attempts to restore it unavailing, the bowel retains for some time its vitality, though both arteries and veins are obstructed, a condition which makes the danger of mortification much more imminent than when the arteries alone are involved.

Agents introduced into the blood.—The calibre of the vessels may be so diminished by contraction of their muscular walls, through the agency of materials taken into the system, as to produce the starvation and consequent death of a part. Of this nature is the mortification following the use of *ergot*,‡‡ which produces a persistent contraction of the muscular coat of the vessels. Or, again, the blood which moves in the vessels may be killed so suddenly by the instillation of a poison, like that of the rattlesnake or the cobra, that an entire limb will fall rapidly into mortification.

Certain kinds of food in which there is no nitrogen, as sugar and gum, when fed for some time to dogs, will produce sloughing of the cornea.

Defective innervation.—Whatever interferes with the transmission of nerve-force from the ganglionic masses to different portions of the body becomes a cause of mortification. This is due to a tardy circulation from vascular weakness in those portions of the body which are imperfectly innervated. Under this head come the sloughs about the nates and limbs of persons suffering from paralysis, or those which follow the division of important nerves, like the median, ophthalmic branch of the fifth pair, and peroneal. The simple pressure of a shoe, or a bandage on the foot of a child that has been the subject of infantile paralysis, may in twenty-four hours produce a slough. To defective innervation may be referred cases of sloughing of the ankle, such as Sir Benjamin Brodie describes as coming on after injury to the spine.

While thus enumerating some of the causes of mortification under distinctive heads, it must not be forgotten that this disease is the result not of any single cause, but of the combination of many; in other words, that destruction is as complex a process as construction.

* Virchow's Archives, vol. xviii. page 557.
† Gazette Médicale de Paris, No. xxvii., 1860.
‡ Gazette d'Hôpital, No. xxiv., 1859.
§ Bulletin de la Société Anatomique, April, 1860.
|| Gazette Hebdomadaire, 1864, page 611.
¶ Dublin Medical Journal, May, 1875, page 476.
** Trans. Med.-Chirurg. Society of London, vol. xxvii. pages 162 and 353.
†† Trans. Med.-Chirurg. Society of London, 1852, page 296; see also page 321.
‡‡ De l'Asphyxie locale, et de la Gangrène symétrique des Extrémités, 1862; Billroth, page 302.

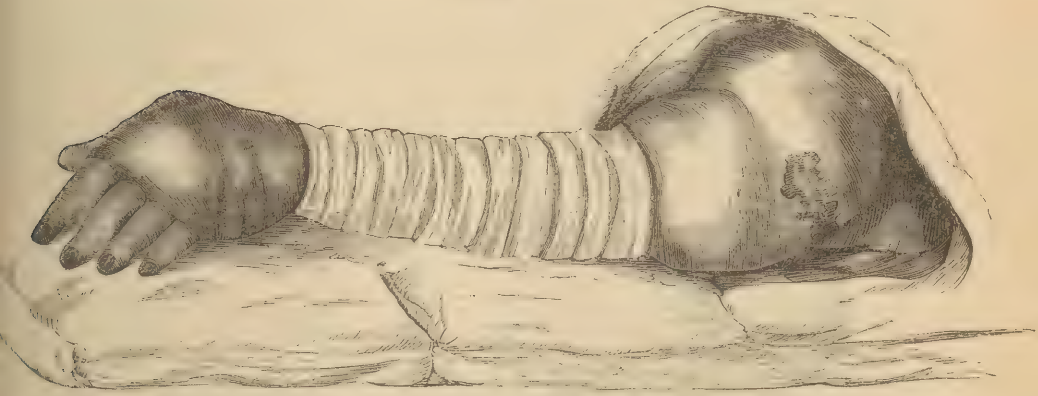
VARIETIES.—There are two varieties of mortification, the *acute* and the *chronic*. These are sometimes designated as the *moist* and the *dry*. Between these two, the acute and the chronic, will be found cases in which the phenomena of both are present, and which therefore partake of a mixed character.

Acute Mortification.

When mortification is of inflammatory origin, the symptoms which precede it are both local and constitutional.

LOCAL SYMPTOMS.—These are intense redness, burning pain, swelling, and heat, with extreme tension of the tissues. They are followed by a change of color, the parts becoming of a dusky-brown or dark-violet color, and afterwards yellow, intermixed with a green, livid, or dark-purple hue. Red streaks appear along the course of the superficial vessels, and the surface assumes a mottled appearance. The temperature falls, the sensibility begins to diminish, the swelling becomes softer and œdematous, and vesicles or blebs rise on the surface, filled with a straw- or dark-colored serum. All these threatening symptoms may be present and yet the life of the part not be extinguished. There may be still circulation, sensibility, and a certain degree of heat; and when in this state its recovery is not impossible. If, however, the progress of the disease is not arrested, a more extensive separation of the cuticle takes place, which, on the slightest pressure, becomes detached, leaving a moist, slippery surface, with a peculiar, offensive, and sickening odor. The color changes to a dark gray, brown, or black. (Fig. 66.) When pressed upon, the parts crackle, from the ichor and gases by which they are interpenetrated. The bloody serum and gases present are the product of blood- and tissue-decomposition, and give to the dead portion a most fetid and disagreeable odor. The accumulation of gas, if the integument or deep planes of fascia remain unbroken, will produce a swelling yielding a peculiar resonance when percussed; but when these tissues give way the parts rapidly shrivel up.

FIG. 66.



Mortification of the arm from a tight bandage.—From Bell.

If a mortified limb be laid open, a marked difference will be observed in its different components. The cellular tissue will present a gray, sodden appearance, detached in shreds or fibres; the muscles will be dark and pulp-like; the tendons but little changed, perhaps beginning to break up into filaments; the periosteum gone, and bones dry and brown; the medullary membrane alive in some cases weeks after all else is dead.

The color which belongs to mortification is the result of the decomposition of the red corpuscles: their coloring-matter, being mixed with the water and

serum, stains not only the cellular tissue about the veins, giving rise to the dark-red streaks which follow the course of the superficial vessels, but, in some degree, all the disorganized components of the affected portion. The chemical changes which ensue upon the destruction of the tissues by the action of oxygen or by oxidation are both numerous and complex. Whatever their intermediate forms, the last result is the formation of carbonic acid water and ammonia. The disgusting odors which emanate from the putrefying mass are not from any single product, but from several, among which are sulphuretted hydrogen, sulphuret of ammonia, valerianic and butyric acids. Several crystalline bodies are also formed, differing according to the structure or organ destroyed, such as ammoniaco-magnesian phosphate, margarin, stearin, tyrosin, and leucin.

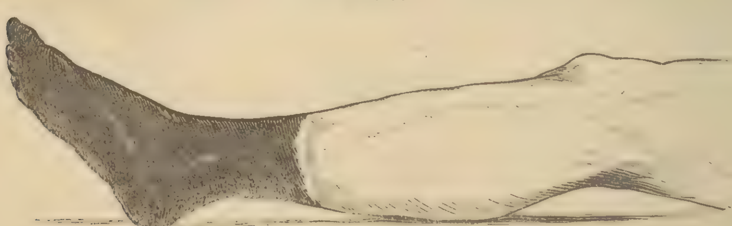
Notwithstanding that the mass consists of dead material, yet, singularly enough, in its midst are to be seen innumerable living organisms, as the aspergillus oidium, or mould, vibriones, bacteria, etc. These forms do not arise by spontaneous generation, but have gained admittance from without. Some writers, such as Pasteur, believe that in the presence of these organisms consists the essence of decomposition or putrefaction; in other words, that they play the part of ferments.

Constitutional Symptoms.—During the early part of the inflammatory stage the pulse is rapid, and possesses considerable force; the temperature is high, reaching four or five degrees above the natural standard; the thirst is intense, accompanied with headache, nervous restlessness, a hot, dry skin, and sometimes delirium. As the disease advances, a marked change takes place: the pulse loses its volume and resistance, becoming feeble and more frequent; the tongue is dry, and of a dark-brown color; the skin moist, with cold, clammy sweats; the countenance anxious, and pinched; the voice feeble; there is great loss of muscular strength, so that the patient is compelled to maintain the dorsal decubitus and slides down in the bed; the urine becomes turbid; occasionally a diarrhœa sets in; there is a disposition to doze, with incoherent muttering; in fine, there are present well-pronounced typhoid symptoms.

The excessive prostration which follows the death of even a very limited portion of the body is difficult to understand. Guthrie* thought it was caused by shock to the nervous system. I am disposed to think, with Brodie and others, that it is due to blood-poisoning: a form of septicæmia induced by the introduction of tissue-sewage into the system.

Separation of the Dead from the Living.—After a variable period, depending on both local and constitutional causes, the dead part or slough is disconnected from the living. The mechanical connection remains some time after the vital one ceases, and this must be severed. While the process

Fig. 67.



Line of demarkation.

of mortification is in progress, from whatever cause, internal or external, an inflammatory work is being done in the parts some distance beyond its limits. This work consists in the infiltration of the structures contiguous to the dead parts with both lymph and leucocytes, erecting in this way a barrier

* Guthrie on Gunshot Wounds, 2d edition, page 123.

against the intrusion of injurious matters into the sound tissues. A red line, which fades away into the adjoining parts, produced by capillary distention, appears beyond the dead skin. This is the line of *demarkation*. It completely encircles the disease, its border being irregular, serpentine, or zigzag. (Fig. 67.) The effect of this inflammatory infiltration is to produce softening and solution of the textures into which it is poured, thus dissolving the connection between the dead and the living parts. Many of the cell components of the affected structures, together with migrated corpuscles, appear as pus, and form a healthy discharge, in place of the fetid and irritating ichor which pours through every crevice of the foul slough. When once this auspicious line is formed and the process of separation fully commenced, it will be announced by the appearance of a groove, showing a loss of substance, which groove continues to deepen by the ulceration which dissolves one plane of structure after another, viz., skin, fasciæ, muscles, tendons, periosteum, and bone, leaving an irregular, serrated surface. The direction taken by the ulceration is never perpendicular, but oblique, the inclination being towards, not from, the slough. (Fig. 68.) When only one or two planes of tissue are mortified, the infiltration is not only around but also beneath the slough. The rapidity with which the ulceration progresses depends upon the nature of the structure. Those which resist longest are the tendons, cartilages, bones, and arteries. In the case of a mortified leg, two or three weeks will suffice to reach the bone, but the latter will require three or four months for its separation. In such cases the bone always protrudes some distance beyond the soft parts, the stump having a conical form. (Fig. 68.)

Fig. 68.

Direction taken by the ulceration in mortification, and the conical form of the stump.

The resistance of the blood-vessels, especially the arteries, to the destructive process is a wise provision to prevent hemorrhage. It gives time not only for their closure by the preliminary clot, but also for the secure obliteration of their canals by organized lymph. The extent to which they are closed is sometimes so great that an amputation of the limb, it is stated, has been made four inches above the dead part without the loss of blood. I have never seen such a case, but do not deny its possibility.

Treatment.—The indications in the treatment of acute mortification are, to remove the cause when possible, limit the destruction of tissue, favor its separation, and support the general system. Depression is the dominating tendency of the disease, and this fact must never be left out of sight. Hence the general abstraction of blood is not allowable. I do not say that in the early period of the precedent inflammation venesection may not, in persons of a robust, plethoric habit, exercise a salutary and controlling power over the local conditions which threaten mortification; but, when the work of death has begun, general bleeding can do no good, but much harm. It may, indeed, destroy the inflammation, but from the tendency to prostration it may also destroy the patient, or at least weaken repair. In many cases of traumatic mortification it is impossible to set bounds to the destruction; but in others, both traumatic and idiopathic, the disease can be greatly circumscribed. The remedies for this purpose are constitutional and local.

Constitutional Treatment.—This consists in rest; regulating the bowels, if necessary, with mild laxatives; alleviating pain and restlessness by anodynes, which last should be conjoined with refrigerants when the skin is hot and dry. The strength must be sustained by tonics, as quinine and iron, stimulants, and nutritious food. Hygienic measures should be rigidly enforced,

such as thorough ventilation, frequent change of clothing and bed-linen, and the free use of disinfectants and deodorants.

Local Treatment.—The local treatment must be regulated by the circumstances attending each particular case. In general, it may be affirmed that the relief of stricture and tension is of paramount importance. Tension and compression of tissue are closely allied. Thus, in a strangulated intestine the stricture must be divided or the gut will perish. When a part is much swollen by the products of inflammation, and begins to present a dark-red, claret, or livid hue, the application of a blister over and beyond the diseased portion—a favorite remedy with Physick—will take off much pressure by inducing a free flow of serum; but where the danger is still more imminent, as in phlegmonous erysipelas, or after a rupture of the urethra, free, bold incisions should be made, sufficiently long, deep, and numerous to unload the tissues of their infiltrated blood, serum, and pus, and thus restore a free circulation through the invaded district.

To favor the separation of the slough, poultices, by promoting a free suppuration, are exceedingly useful. They should be mixed with such substances as will absorb and destroy all odors emanating from the decomposition of structure. A little charcoal, yeast, or porter mixed with flaxseed- or cornmeal will answer a good purpose. The poultice should be renewed three or four times in the twenty-four hours, according to the amount of liquid products or sewage flowing from the slough; and at each renewal the parts should be thoroughly cleansed with a solution of the permanganate of potash or chlorinated soda. When the structures are entirely dead and become loose, they may be clipped away with the scissors; never, however, cutting into points where there is the least evidence of vitality, for fear of provoking a dangerous bleeding. Nature can effect the separation much better and with greater safety than the surgeon; and it is a rare occurrence, where there has been no meddling, for the separation to occur before the vessels have been sealed.

When the slough is disengaged and ejected, we have to deal with a simple granulating ulcer. Poultices should then be laid aside and the use of water-dressings substituted.

Hemorrhage.—Should this follow in the course of detachment, a strong solution of alum-water should be applied, conjoined with pressure; this failing, we may resort to the hot iron; and, as a last recourse, to ligature of the supplying artery.

Amputation.—Cases will be encountered in which the subject of amputation comes up for consideration. This will, in many instances, demand the most discriminating judgment, and it is one upon which surgeons do not altogether agree. In deciding upon so important a question we are to consider that mortification must be referred to one of the three following classes of causes: local, general, and mixed. When the cause is purely local (and by local I mean confined to the visibly damaged part), the knife can go above the disease; when general, it cannot; when mixed, it may or may not. The last forms the debatable ground. Let us make a practical application of these general statements.

First. In all cases of traumatic mortification extensively involving the components of a limb, where the line of demarkation is established and the strength of the patient is not too greatly exhausted, there can be but one opinion as to the propriety of amputation: this should be done as near to the line of separation as will allow of the formation of a sufficient flap.

Second. In incipient traumatic mortification,—that which begins within what is called the primary period (from thirty-six to forty-eight hours),—the surgeon should operate at once, without waiting for any line of separation, provided the patient's general condition will allow. Gangrene from extremes of temperature, such as heat or cold, constitutes an exception to this rule: in such condition amputation must be preceded by the line of demarkation.

Third. In cases of traumatic mortification, where the disease is well estab-

lished and rapidly progressing without any line of limitation, an operation is not allowable, because the surgeon cannot know where to apply his knife. Such a case has more than a local significance; it belongs to the mixed class; that is, the effects of the injury are not confined to the surface of contact with the vulnerating body, but extend to the vascular and nervous structures of the entire limb, with often the presence of a general factor, as, shock to the system, concussion of the spinal marrow, a heart defective in power, or a diseased state of the kidneys. We must wait for nature's sign, the line of demarkation. I know this opinion is directly antagonistic to that of several very eminent surgeons; but I am so thoroughly convinced of its correctness that I can make no modification of this rule, at least in civil practice.

Fourth. When mortification is due to embolism or ergotism,—in the one case obstructive and in the other anæmic,—or to any cause that has not a local explanation, general causes are in operation, and the knife must be withheld until the limitations are fixed, when, if the strength of the patient does not forbid, the amputation may be done.

Fifth. When mortification follows the application of a ligature to an artery, as the brachial or femoral, the case is purely a local one, the collateral branches being unable to convey blood to the parts below, and therefore there is no necessity to wait for a line of demarkation; the limb should be removed above the seat of the ligature.

Sixth. When mortification follows an injury to a main artery, either from gunshot or other violence, the cause is a local one, and therefore there is no necessity for delay; the limb should be removed above the point of injury. The death of a part after such a damage is analogous to that which sometimes follows the ligature.

Chronic Mortification.

In striking contrast with the disease just described is the one now under consideration,—chronic or dry mortification. In the first or acute variety the disease is preceded, when it arises from inflammatory causes, by the usual symptoms of redness, heat, pain, and swelling; in this form, inflammatory signs are either entirely absent or are very imperfectly expressed: in the first, the parts are mottled, swollen, and œdematous; in this, they are dark, shrunken, and hard: in the first, the liquid products of decomposition are abundant; in this, the tissues are dry and mummified: in the first, there is odor; in this, none is recognized. Dry mortification, though commonly a disease of advanced life, may occur at an earlier period. I have seen it in two young men under twenty-five years of age, and cases are recorded in children under twelve. Males are more commonly the subjects of the disease than females. It does not always assume the characters detailed, but may occasionally resemble the acute humid form, especially in those cases having an inflammatory history. Under the name of "gangrene of the toes and feet," it was first discovered by Pott, of London; and it is often designated as *senile gangrene.*

Causes.—There are several causes which are influential in producing the disease, among which may be mentioned a feeble, fatty heart, incapable of propelling the blood with vigor into the remote vessels of the extremities, in consequence of which a capillary stagnation takes place, extending into the larger branches of the arteries; also calcification of the arterial tissues, destroying their elasticity,—a condition recognized long ago by Cowper,* and also by Becket† and Thompson.‡ This change in the arteries, giving rise to irregularities of surface, tends to interfere with the smooth and regular flow of the blood, inducing the formation of thrombi and the detachment of fibrinous plugs which serve to obstruct either a main trunk or some of the small ter-

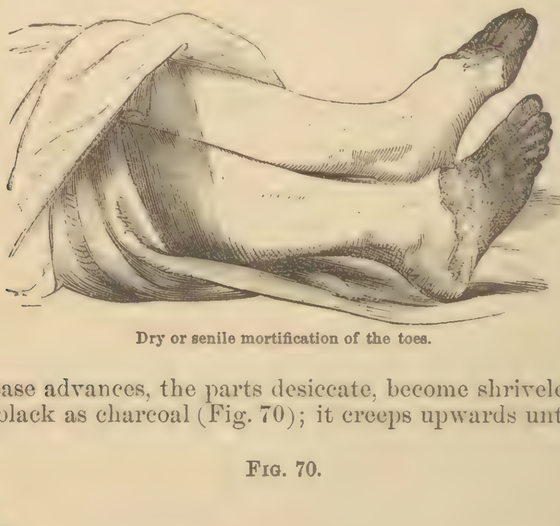
* Philosophical Transactions, vols. xxiii. and xxiv., pages 1195 and 1970.
† Becket's Chirurgical Observations.
‡ Thompson on Inflammation, page 537.

minal branches. The disease is no more common in persons who have been addicted to the pleasures of the table, or whose constitutions have been ruined by excess, than in those whose lives have been regular in every respect. The last four cases that came under my notice were in men who had been remarkable for possessing sound and vigorous bodies,—three of them farmers,—and who, up to the time of their attack, enjoyed excellent health.

SYMPTOMS.—The approach of the disease, especially when of the acute type, is sometimes indicated by signs of constitutional indisposition, which, however, are usually so slight as to attract but little notice. These signs consist in diminished appetite, loss of strength, frequent and often irregular pulse.

Local disturbances also foreshadow the disease. There is increased sensibility, the toes and feet becoming painful, or the latter may feel heavy and benumbed. Darting pains sometimes shoot through the toes and up into the limbs; the temperature falls; the patient complains of cramps, and finds it difficult to maintain a comfortable warmth in the foot. In some instances all monitory signs are absent, and the first announcement of the disease is the appearance of a brown spot, sometimes not larger than a pin's head, on one or several of the toes. On this a vesicle may or may not arise. This spot becomes darker, and finally black; it slowly extends, sometimes with, often without, any marginal redness; and the pain is frequently very intense, is paroxysmal, and depressing. (Fig. 69.)

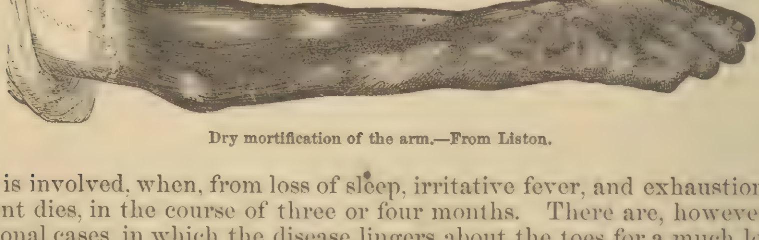
FIG. 69.



Dry or senile mortification of the toes.

As the disease advances, the parts desiccate, become shriveled, contracted, hard, and as black as charcoal (Fig. 70); it creeps upwards until most of the

FIG. 70.



Dry mortification of the arm.—From Liston.

limb is involved, when, from loss of sleep, irritative fever, and exhaustion, the patient dies, in the course of three or four months. There are, however, exceptional cases, in which the disease lingers about the toes for a much longer period of time, and where undoubtedly the occlusion of the vessels is limited or imperfect. Sometimes, though rarely, a line forms, the part drops off by ulceration, and the surface cicatrizes, the patient recovering as by a miracle.

In other cases the disease partakes of the acute form. The toes assume a dark-red color, become swollen and exceedingly painful; the parts above present a mottled appearance from embarrassed circulation; blebs or phlyctenulæ rise over the surface, filled with bloody serum; the subcutaneous tissue undergoes a rapid decomposition and becomes filled with liquid matters, from which emanate the foulest odors. The patient soon begins to suffer from septicæmia; the pulse becomes frequent and feeble, the tongue dark, profuse sweats break out over the surface of the body, the mind wanders, the hands become tremulous, and the sufferer dies in a typhoid condition. Very recently I saw, in the same family, two cases of senile mortification of the feet,—father and son. In the father's case the malady was of the slow, dry, chronic form; in that of the son it was of the acute variety. The latter died in six weeks; the former lived about three months.

There is a variety of chronic mortification which is believed to depend upon the use of food containing *ergot*, and which formerly prevailed to a considerable extent in Germany, Switzerland, France, and other parts of the continent of Europe. It was first described by Dodard* in 1676. A number of cases were brought into the Hôtel-Dieu at Orleans, in which, as Saviard, in 1694, informs us, the upper as well as the lower extremities were affected. No age was exempt from its ravages. Pereira† supposes that this disease was a very ancient one, and that it was this affection which Sigebert and Bayle described as prevailing in 1089 in certain parts of Lorraine, in which the hands and feet became black and rotted off. The last author makes allusion to the peculiar color of the bread consumed by the people. The disease was described by Noel, in 1710, in a memoir to the Royal Academy of Sciences in Paris. The year before (1709) it would appear that one fourth of all the rye in certain provinces of France—as, for example, Sologne—was affected with the ergot, and it is not surprising, therefore, that we read of five hundred cases entering the hospital at Orleans. Its appearance in Switzerland in 1809, and again in 1816, formed the subject of a paper by Langius. In Dauphiny it was described by Gassoud and Bossau in 1709. In consequence of certain investigations made by Model,‡ from which he deduced the conclusion that the lower animals were exempt from the disease, the Royal Society at Paris enlisted the services of Tessier, who made numerous careful experiments with a view to determine the truth of this allegation, and while it was found that animals resisted for a long time the baneful effects of the grain, yet they finally perished from this form of mortification. Similar experiments, in 1811, were instituted by Block,§ which did not, however, sustain those of Tessier, as large quantities of the ergot were fed to animals, such as sheep and cows, for periods varying from four weeks to three months, without any manifestation of the disease. Notwithstanding these contradictory statements, our present knowledge of the action of ergotin in producing contraction of the muscular coat of the vessels furnishes strong evidence that the popular notion that this mortification was due to the diseased rye was correct, although it is highly probable that to produce its peculiar effect the contaminated flour must be used for a considerable length of time. I am not aware that the disease is ever seen in this country, although it is alleged that, during the years 1819 and 1820, cattle, both in this State and in New York, died from this cause, having eaten the diseased grain of meadow-grass. I have seen it on this rich and luxuriant grass to a much greater extent than on rye. The disappearance of the disease from those regions where it formerly prevailed is doubtless due to two causes, viz., the substitution of wheat for rye in the preparation of bread, and the introduction of mechanical appliances, such as the smut-machine so generally in use, for the removal of all matters foreign to the sound grain before it is ground into flour.

* Journal des Savans, 1676; Cooper's Surgical Dictionary.
† Elements of Materia Medica, Part II., 1840.
‡ Dictionary of Natural History, Bomare, vol. xix.
§ Chelius's Surgery, by South, vol. i. page 75.

The disease, as described by those familiar with its appearance, begins in one or both feet, and is attended with a burning heat, redness, and pain sometimes excruciating. In the course of four or five days these phenomena disappear, and the parts become cold, black, and insensible, without odor, and thoroughly desiccated. In some instances there is considerable swelling, attended with fever and delirium. Occasionally the mortification partakes more of the moist kind, with putrid emanations. In exceptional cases a line of separation forms and the dead part drops off; though generally the disease advances up the limb until the patient is destroyed; and in a case narrated by Thompson both limbs sloughed off at the hip-joint.

Prognosis.—The prognosis in chronic mortification is exceedingly unfavorable. In young subjects, or when produced by embolism from blood-change, there is a prospect of limitation and of the recovery of the patient after amputation. A line of demarkation occasionally forms, the parts separate, and cicatrization follows. Such a termination, however, is so rare that it does not affect the general rule,—namely, death, in a period of time varying from eight weeks to four months.

Treatment.—The disease is one which rapidly exhausts the powers of the system, and demands unceasing support: consequently, the most nutritious articles of food are requisite, which should be assisted by tonics, such as quinine and the tincture of the chloride of iron. In the use of stimulants the surgeon must be guided by their effects: should they produce restlessness and too much warmth of surface they should not be given. To relieve pain and procure sleep, opium in some of its forms should be freely administered, either by the mouth or hypodermically. Constipation must be corrected by gentle aperients, otherwise the opium will produce headache and disturb the digestion.

Local treatment is limited to maintaining the warmth of the limb by enveloping it in some non-conducting substance, like cotton batting. After using a great variety of applications, I am disposed to believe that all are alike valueless; but when any odor is present the dead part should be surrounded with a piece of lint moistened with phénol sodique and covered with oiled silk. The position in which to place the part can only be determined by consulting the patient's feelings, some deriving the most comfort in the dependent and others in the horizontal posture. There can be only one justification for a resort to amputation, and that is the formation of a line of demarkation; and even then the strength of the patient must be equal to the shock and to the work of repair. Not only should this separating line be formed, but the ulcerative process should be well established, before the knife is applied. I have seen the disease remain stationary for two or three weeks, an imperfect line form, and afterwards the mortification break over this depression and progress. In one case of this kind I was urged to operate, but declined; another surgeon was induced to remove the dead part, but the disease appeared at once in the stump, and advanced with singular rapidity to a fatal termination. When amputation under the limitations above specified is performed, it should be done as near as possible to the ulcerating surface, where the co-operation of nature will assist in the work of restoration.

HOSPITAL MORTIFICATION.

This disease has been described under different names by different writers, as *gangræna contagiosa*, *phagedæna gangrænosa*, *gangræna nosocomialis*, *putrid ulcer*, *pulpy gangrene*, *pourriture d'hôpital*, *hospital gangrene*, *diphtheria of wounds*, etc.

In this country it is generally known as *hospital gangrene*. It has been the scourge of military hospitals, camps, and naval transports; it has invaded prisons, and occasionally has appeared in civil hospitals. The propriety of discussing the disease in its present connection may be questioned by some,

and with a certain degree of force. Being a complication, in most instances, of wounds, it would seem most fitting that its consideration should be reserved for that division of our subject. Yet, being a species of a generic process,—that of mortification,—there can be no inconsistency in treating of it in the present place.

The existence of a wound is a necessary condition to its development. This need not be large: any breach in the continuity of tissue—a scratch, the prick of a pin, the sting of an insect, or a contusion—will offer a surface for its development. Bryant* informs us that when it prevailed in the wards of Guy's Hospital, London, in 1849, contusions were often attacked. I can find no evidence which will require any modification of the statement that for the development of the disease an open surface is necessary. We know very well that contusions which recover without vesication or ulceration in healthy wards will not do so in a vitiated hospital atmosphere. This is due, not to local impressions, but to a contaminated state of the air entering the system through the lungs, which vitiates the blood, and through this medium impairs the function of those nervous ganglia whose action is so necessary to repair. If under such unfavorable conditions inflammation follows a contusion, and a little vesicle or ulcer results, removing thereby the cuticle which usually forms, when intact, an impenetrable coat of mail against the admission of morbific agents, then the enemy, whatever it may be, will enter, and the mortification follow. Although I witnessed a large number of cases of this disease during the late war, in no instance was there a single idiopathic case.

It may prevail in two forms,—the *endemic* and the *sporadic*. In the first, scarcely a single open surface, from whatever cause, within the affected district, will escape. In the second, the disease appears to be confined to isolated cases and sores of a specific nature, as chancre and open cancer. These ulcers, it is alleged, are more liable to suffer from the latter than from the former variety, and I have witnessed in the Philadelphia Almshouse facts corroborative of this statement.

Causes.—In our present state of knowledge we are not prepared to speak with any certainty on this subject. It is certainly not due to dirt or to a broken-down constitution, or to both together, since we learn from Macleod† that the barrack hospital at Scutari, which was very offensive and overcrowded with enfeebled soldiers, suffered no more from the disease than did others in a much better situation. During the War of the Rebellion it was frequently seen to attack the strong and vigorous while the feeble escaped, though, as a rule, patients enfeebled by loss of blood or from any other cause are most liable to the disease. Neither is it due to overcrowding alone, as this has often happened without the appearance of a single case.

Not one of these conditions existed as I saw the disease at the Chestnut Hill Military Hospital, nor in the De Camp and McDougal Hospitals, as related by Hamilton;‡ yet that these are material factors favoring an outbreak of the mortification can scarcely be questioned. These, with certain subtle or occult states of the atmosphere, may call into activity organisms which, floating in the air or adherent to instruments and dressings, come in contact with open surfaces and destroy their life. On this subject everything is conjecture. The disease may prevail at any season of the year. A moist or damp atmosphere, however, seems to be peculiarly favorable to its development.

It is both contagious and infectious; that is, it is capable of being propagated by contact, and also through the medium of the atmosphere. In proof of the first, it is stated by Holmes Coote§ that during the appearance of the disease, in 1846, at St. Bartholomew's Hospital, its extension in two instances was unmistakably traced to the use of an infected sponge. A putrid slough taken from a case of hospital mortification and applied to a healthy wound

* Bryant's Surgery, page 435.
† Crimean War, page 166.
‡ Hamilton's Surgery, page 61.
§ Holmes's Surgery, vol. i. page 164.

will communicate the disease to the latter. The observations of Pouteau show that a sponge or lint bearing the discharges from the pulp of an infected sore will communicate the disease to a healthy ulcer, though the constitution of the patient and the hygienic surroundings are of the best kind. Its infectious nature is rendered probable by the appearance of cases at the extreme parts of a ward, the intermediate ones escaping,—and that, too, in instances where neither instruments, dressings, nor personal contact could explain the fact. In point, also, is the statement of Guthrie in his Commentaries,* that hospital gangrene which was confined to the lower wards, at Leyden, in 1798, broke out in the upper wards thirty hours after the surgeon, in order to obtain better ventilation, broke an opening through the ceiling, thus forming a communication between the two rooms. Those nearest the opening were first attacked, the disease extending afterwards throughout the apartment.

Von Pitha and Fock believe that the disease has a miasmatic origin.† The tenacity with which this materies morbi clings to substances which have been in use as dressings during the disease is well shown in the circumstance narrated by Guthrie, that lint which had been used to dress the sores of hospital mortification in Paris, although it had been washed, dried, and bleached, yet, when sent to Holland, poisoned every wound to which it was applied.

The division of hospital mortification into the *ulcerous* and the *pulpy* is one without much practical value, the difference being only in the amount of tissue involved. In the first the parts die in small installments, in the second in large masses.

Symptoms.—These are *local* and *constitutional*. The first play the most important rôle, and, I doubt not, precede the former. I mean by this that the constitutional symptoms are the result of the inoculation.

Local Symptoms.—These vary much in different cases. When the disease attacks a contused part, or a welt,—which, under the old system of flogging, was not an uncommon occurrence,—a vesicle first forms, filled with bloody serum, partly covered, most likely caused by the violence. This vesicle opens and discharges, forming a sore, the pain of which is burning and pungent. The parts around become livid, and a gray slough forms. The contact of this dead mass with the living gives an increased impetus to the disease, and it extends rapidly. When an open surface, like an ulcer or amputation, is invaded, the previously healthy or purulent secretions are arrested, the surface becomes dry, and the granulations pale. The sore is soon covered with a whitish exudation, or with minute blood-clots and gray sloughs. Hitherto devoid of any unusual sensibility or odor, it now becomes tender, painful, and offensive; the parts on the border of the ulcer are swollen and livid, while beyond they are of a dark-red color. The edges are sharply cut, with a tendency in the sore to become round in form; afterwards they become ragged, everted, or sunken. The minute sloughs scattered over the surface become confluent, so that in a period of thirty-six or forty-eight hours the whole ulcer is converted into a dead, ash-colored mass, with an exuding ichorous discharge. Even far beyond the limits of the sore the skin may be undermined by the extension of the disease through the underlying connective tissue, a condition which is not uncommon when the mortification attacks the track of a ball. It is in the connective tissue that the disease produces such formidable devastation, so formidable that a large portion of the muscles of a limb may be uncovered in a very short time. Muscular tissue resists the process much longer than do the fasciæ. The destruction is sometimes so rapid that even the blood-vessels, which usually are slow to yield to common forms of mortification, give way, followed by frightful hemorrhages; and the bones, denuded of their periosteum, become black and necrosed. In such aggravated instances the sewage from the putrid sloughs

* Bryant's Surgery, page 435.
† Billroth's Surgical Pathology, American edition, page 322.

sometimes enters the lymphatics, contaminating the glands with which they are connected,—as the axillary or inguinal,—and gives rise to suppuration, thus establishing a new focus of death.

Constitutional Symptoms.—In some cases a certain degree of general indisposition is experienced before the local symptoms are recognized. The patient may complain of headache, a sense of constriction across the forehead, and loss of appetite, with a loaded tongue and an accelerated pulse; but in the cases which have come under my own observation the topical preceded the constitutional signs. When, however, the local disease proves unusually destructive, the system sympathizes to a marked degree; the pulse becomes feeble and frequent; a cold perspiration bedews the surface; the countenance assumes an anxious expression; the breathing becomes oppressed; the tongue is sometimes dark brown, at other times yellow; the stomach is irritable; spasmodic twitchings attack the limb, greatly aggravating the pain experienced about the sore; the mind wanders, and the prostration, which rapidly increases, is followed, unless the disease is arrested, by death in a period of from nine to fourteen days.

Prognosis.—When the necessary resources are at hand, and are promptly used, the prognosis is highly favorable. Nothing can be more striking than the immense superiority of the modern modes of treatment over those in use among the older surgeons. This superiority is due to sounder notions of the nature of the disease, it being now regarded as a local rather than a constitutional disorder. The mortality during the Peninsular War, in 1813, amounted to one-third of the cases attacked. During the Crimean contest, as we learn from Macleod, the fatality was very much less. The deaths from this cause in the War of the Rebellion were very few indeed, and when an unfortunate termination did occur it was from hemorrhage, from suppuration following extensive destruction of the soft parts, from exposure of joint-cavities, or from septicæmia wearing the sufferer out through sheer exhaustion, and occasionally from the implication of some important organ.

Treatment.—First in importance is a change of place,—a removal from the infected district,—and, if the weather is not too inclement, the erection of hospital-tents in the open air. When the gangrene broke out at the Chestnut Hill Hospital situated near Philadelphia, it was arrested in twelve hours by removing the affected patients into an adjoining grove of chestnut timber. Should the latter plan be inadmissible, a separate building, thoroughly cleansed and ventilated, must be secured. In this change of place, everything connected with the affected ward must be left behind, nurses, beds, bedding, sponges, instruments, and dressings, and a fresh supply of each provided; while an abundance of chloride of lime should be distributed about the new quarters.

Local Treatment.—This is next in importance, and consists in disinfecting and deodorizing the adherent slough, arresting the ulcerative process, and exciting a healthy inflammatory action beyond the limits of the sore. Caustics are the most potential for these purposes, and there are two which transcend all others in value,—nitric acid and bromine. The mineral acids were first used by Mr. Guthrie, at Santander;* and bromine by Dr. Goldsmith,† during our late war. Preliminary to the use of either, if the disease is extensive, the patient should be moderately etherized, as their application is attended with considerable pain. With a pair of scissors and forceps all loose and disorganized parts of the slough should be clipped away, and the surface cleansed with a wash of permanganate of potash (three grains to one ounce). Next, with a mop made by securing a piece of lint or a dossil of cotton to the end of a stick, the fuming nitric acid or the undiluted bromine should be worked into all the interstices of the slough, or, if this is too compact, its parts should be broken with a director, so that it may be freely interpenetrated by the caustic in every direction as deep as the living tissue.

* Commentaries on Surgery, page 161. † American Medical Times, Sept. 12, 1863, page 121.

Near the attached portions of the slough, openings may be made at short intervals with the director, and the acids thrown in with a glass syringe. Where the parts are rapidly breaking down, as in the ulcerative variety, the simple application of these agents to the circumference of the disease will arrest the destruction. The surface thus converted into a charred mass should be covered with a flaxseed-meal poultice sprinkled over with charcoal; or with a warm-water dressing medicated with a little phénol sodique or a very weak solution of bromine (one part to twelve of water). If the caustic application has been thoroughly made, its repetition will not be necessary. The sewage from the dead pulp will be destroyed, and the molecular decay arrested. In this way inoculation of the contiguous structures is prevented, and a healthy inflammation established. The transudation which follows such inflammation will not only disjoin the dead from the living, but will also furnish the granulations necessary to restore the chasm. As soon as the granulations form, a simple ulcer results, and the sore should be managed as directed under the head of Ulceration. Other preparations have been used, and with highly beneficial effects, as the acid nitrate of mercury, by Professor Gross; the permanganate of potash (one drachm to one fluidounce of water), by Dr. Hinkle, of Marietta (also a favorite remedy with Dr. Ashhurst); lactic acid, by Professor Jackson; spirits of turpentine, by Dr. Hackenberg; tar-water, by Dugas, of Georgia; sugar or syrup, by Dr. Packard; and butter-milk, by Dr. W. F. Atlee. Monsel's solution, iodine, chlorinated soda, and creasote have all had their advocates. Among the French surgeons the actual cautery was, at one time, much in use. In cases attended by hemorrhage the hot iron or the galvano-cautery would be desirable, as furnishing the most certain means of controlling the bleeding, as well as of destroying all the specific characters of the slough. Should the hemorrhage continue to recur, a ligature must be applied to the bleeding vessel; if practicable, at the seat of disease. Dr. Weeks, Surgeon U.S.V.,* tied the dorsalis pedis in one case, the anterior tibial in another, and, in a third, the brachial artery, with success, applying immediately afterwards the bromine. Pressure by means of an acupressure-pin will answer a good purpose in cases where the artery is accessible.

Constitutional Treatment.—This should be supporting throughout. The bowels must be regulated, if required, by gentle laxatives, such as the sulphate of magnesia, a Seidlitz powder, or a rhubarb pill; pain and restlessness must be subdued by the free use of opium, and the strength maintained by quinine and the tincture of the chloride of iron, together with a diet consisting of concentrated animal broths, milk, milk-punch, and eggs.

Throughout the whole treatment there should be the most rigid enforcement of every hygienic precaution. All instruments used in the wards should be cleansed and kept in a carbolic acid bath (one part of acid to twenty parts of water). No sponges should be employed; wads of oakum answer every purpose for washing, to be thrown away immediately after using. The soiled dressings, as they are removed and placed in a vessel, should be sprinkled with a solution of the permanganate of potash and then destroyed by fire. The clothing of the nurses, as well as that of the patient's bed and person, will demand frequent change, and a constant supply of fresh air, with thorough ventilation, is of the first importance.

In consequence of extensive destruction of the soft parts, laying bare the bones, or opening joints, amputation sometimes becomes necessary; in this event the surgeon should delay not only until the separation is accomplished, but also until repair has been well established, when, if the strength of the patient allow, he should be isolated and the operation performed.

* Hamilton's Surgery, page 70.

History of Hospital Mortification.

As with the early history of many other diseases, that of hospital mortification is involved in much uncertainty, and while authors discover a knowledge of this disorder in the allusions made to certain forms of ulcerations by Aetius, Avicenna, Rolandus, and others, still, all is mere conjecture. I doubt very much whether the disease existed, save perhaps in a sporadic form, antecedent to the discovery of gunpowder and the construction of fire-arms. It was only after the introduction of these into the contests of nations that war became very destructive, or that large numbers of wounded men were likely to be suddenly massed together. Then, again, the construction of hospitals, and especially of military hospitals, was an outgrowth of Christian civilization, and, on anything like a colossal scale, is of very modern date.

Richard Wiseman, surgeon to Charles II., alludes to the ravages of a disease which attacked wounds, and in his quaint language says, "the lips sink and are flaccid, a gleet followeth, and the flesh within withers; also the pulse and the sense in the part do both languish."*

The first distinct allusion to the disease was made by La Motte, in 1722, in his treatise on Surgery. It had appeared at the Hôtel-Dieu in Paris, and was first named by him *pourriture d'hôpital*. It is only, however, after the publication of the works of Pouteau,† sixty-one years later, that we find a clear description of this form of mortification. Pouteau's knowledge was drawn from cases in the Hôtel-Dieu at Lyons; and when a dresser in this hospital he had himself suffered from the disease.

In 1785, Gillespie,‡ an assistant surgeon in the English navy, published a paper on the same subject, under the title "Observations on the Putrid Ulcer." He mentions its prevalence among the seamen landed on Pigeon's Island, St. Lucia, in 1781, where a naval hospital was established. At the same time the inmates of the naval hospital at New York, at least those from the West India squadron, suffered much from the affection, though there was in both a scorbutic element. In 1788, Dussassois,§ one of the surgeons of the Hôtel-Dieu at Lyons, published an article on the same subject. Both he and Gillespie regarded the disorder as infectious. In 1796 two pamphlets appeared,—one by Moreau and the other by Bourdin, both Frenchmen;‖ but according to Thompson "these papers added nothing new to our knowledge of the disease."

Rollo,¶ in 1797, devotes a chapter in his book on Diabetes to a "sore acted on by a new or overlooked species of matter," and which is supposed to correspond to hospital mortification. In 1799, Dr. Blane speaks of the disease prevailing very much in ships, and in the naval hospital at the Cape of Good Hope, in so severe a form that even bones like the scapula and the ilium were attacked. The same year Dr. Trotter** described the disease, and among its peculiarities he mentioned an irregularity of the sores, which gave to their edges a deeply-indented form. John Bell,†† in 1801, treats of hospital gangrene, and, in the course of his remarks, says that "no dressings ever can cure the disease,"—rather a rash assertion in the light of modern therapeutics; though he very justly adds that the only safety for the patient is outside of a hospital air. In 1804 and 1805, Dr. Thompson‡‡ says, "two theses of high merit were written—one by Dr. Leslie, the other by Dr. Johnson, students in the University of Edinburgh—on this form of gangrene."

* Chirurgical Treatises, vol. ii. page 213, 5th ed., 1719.
† Posthumous Works, vol. iii., 1783.
‡ Gillespie on Putrid Ulcer, London Medical Journal, vol. vi. page 373.
§ Dussassois, Gangrène des Hôpitaux.
‖ Sur la Gangrène Humide des Hôpitaux, 1788.
¶ Diseases of Seamen, by Rollo.
** Trotter, Medicina Nautica, vols. ii. and iii.
†† John Bell, Principles of Surgery.
‡‡ Thompson, Lectures on Inflammation.

In 1804* two papers were published on the subject,—one by Ballard, and the other by Harness, both connected with the Royal Navy.

In 1806, Marshall, in a letter to Ballingall, attributed the occurrence of the disease in the Feversham Hospital to the use of infected sponges; and in 1809, Mr. Lyttle, also of the English navy, wrote a treatise, in which he declares that this gangrene caused the loss of more men to the naval service than all other diseases incident to seamen.†

Sir James McGrigor, Chief Medical Director in the Peninsular War‡ of 1813, also speaks of the disease in a letter to Ballingall, and attributes its prevalence to the unhealthy sites of hospitals, conjoined with a pre-existing enfeebled state of health in the patients. In the same year Dr. John Thompson§ devoted to this subject a carefully-prepared chapter, or rather lecture, at the end of his book on Inflammation, in which he expresses his preference for the term *putrid ulcer*. Though it is alleged that specific sores are not liable to be attacked by this mortification, yet he mentions cases of open cancer, and chancre, which he had seen repeatedly become the seat of disease. Its contagiousness he admits, and recommends, as the best means of managing the disease, separation, cleanliness, and ventilation, followed by the use of emetics and purgatives, and, locally, the use of turpentine with resin ointment. He opposes the use of opium, wine, and a full diet, especially in the commencement of the disease, and recommends the employment of bloodletting. He states that the gangrene often attacked wounds made by the lancet.

Baron Larrey, notwithstanding that he must have been quite familiar with this mortification, has nowhere given to it more than a very meagre notice. In Egypt the disease was peculiarly fatal, the men dying in a few hours‖ and presenting appearances like those of yellow fever. In his "Chirurgie Militaire" it is scarcely alluded to. He recommends quinine, opium, and the actual cautery.¶ In his "Memoirs of Military Surgery"** he speaks of the epidemic disease of Brunn, in the campaign of Boulogne, as appearing among the French and Russian wounded. The wounds in which suppuration was first developed were affected with hospital putrefaction, which spread with great rapidity. The odor proved infectious, attacking those who were near, and also the medical attendants. The disease likewise made its appearance in the Hôpital la Charité, distant from the others and perfectly clean. In his "Observations on Wounds and their Complications"†† he insists on a difference between ordinary gangrene and hospital putrefaction, having witnessed both in the campaigns in Germany. His local treatment consisted in the use of Labarraque's solution and the cautery.

In 1815 there were four valuable contributions on the subject, by Hennen, Brugmans, Delpech, and Aubry. Hennen‡‡ had encountered this scourge of military camps first in the Cordeleria Hospital at Bilboa, a hospital admirably located on a gravelly soil, four miles from the city, six miles from the sea, and on the bank of a river. When it broke out, the prevailing winds were from the sea, the thermometer ranging between 68° and 78°. The arteries rapidly sloughed, followed by hemorrhage, and the ligatures, which were placed on the vessels above, separated in a few days, giving rise to exhaustive and fatal bleedings. He never saw the lancet or cupping wounds attacked, as stated by Thompson; and he says that a remarkable feature of the disease was its tendency to change all sores into a circular form, whatever

* Blackadder, Observations on Phagedæna Gangrænosa, Edinburgh, 1818.

† Malignant and Contagious Ulcer.

‡ Medico-Chirurgical Transactions, vol. vi. page 455.

§ Lectures on Inflammation, page 369.

‖ Larrey, Military Surgery, vol. ii. page 18, Translation by Hall, 1814.

¶ Larrey, Clin. Chirurg., 1829, vol. i. page 72.

** Memoirs of Military Surgery from 1792 to 1812, vol. i. page 412, and vol. ii. page 1, Translation by Hall, Baltimore, 1814.

†† Op. cit., Translation by Rivinus, Philadelphia, 1832, page 48.

‡‡ Observations on Military Surgery, Edinburgh, 1818; also London Medical Repository, March, 1815.

may have been their previous shape. In the Gensdarmerie Hospital at Brussels, which was filthy, there were three hundred wounded men, and among them one hundred and forty cases of compound fracture, many of whom had lain from one to two weeks after the battle of Waterloo without dressings; and here the fatality was frightful. In the Elizabeth Hospital, at Brussels, which was clean, there were only a few cases. At the hospital on the Antwerp Canal, out of the city, and which was crowded, this gangrene attacked the stumps three hours after amputation, and so rapid and destructive was its progress that in twenty-eight days there was but a single surviving stump. A few cases were seen presenting the phenomena of yellow fever, such as were described by Larrey. Hennen advocated bleeding, the use of the fermenting poultice, and, in aggravated cases, the cautery.

Brugmans, of Leyden,* analyzed the air of infected wards, and claimed to have discovered a peculiar animal matter having a tendency to putrefaction and which he supposed played an important part in the production of the disease. It is this writer whom Guthrie quotes as saying that "when the disease existed in Leyden in 1798 it was communicated from a lower to an upper ward of the hospital by cutting an opening between to improve the ventilation:" hence he argued its contagious nature, and claimed also that its introduction into Holland was through charpie sent from French hospitals.

Delpech† attributed to the depressing influence of defeat much of the mortality among the French from this mortification: despondency, however, is one of the symptoms of the disease. He treated successfully one hundred and fifty cases before Pampeluna with the actual cautery, and concluded, after a careful study of the disorder, that it was communicated to wounds by poisonous exhalations.

Aubry‡ saw this gangrene in Prague, in 1814; in Rouen, in 1812; and on a vessel bound from Spalatro to Zara, in 1807. He believed in its communicability by contact, and mentions the case of a surgeon at Prague who wounded his finger and in four days suffered from an attack. He also pointed out the distinction between this sore and ulceration, and was an advocate of the use of opium internally, with that of vinegar locally.

In 1818, H. H. Blackadder,§ surgeon to His Majesty's forces in the Peninsula, published a monograph on this form of mortification, in which the subject is treated in a learned and exhaustive manner. He regarded the disease as purely local and contagious. While examining the stump of a patient who had died of the disease, he became inoculated through a scratch in the finger. Pain and inflammation set in sixty hours after the accident, and in four days had extended up the arm, followed by rigors and headache. It was two months before the sore cicatrized, and six months before the natural color of the part returned. Blackadder was a strenuous advocate for arsenic, which he applied, in the form of Fowler's solution, directly to the wound. This remedy was used also by Higgins, after the battle of Waterloo, at the hospital at Antwerp, and at the same place by O'Connel.‖ No instances of poisoning were observed. In order to settle the question of its contagious nature, Ollivier¶ inoculated himself in 1810; a vesicle formed, and ran a regular course until the fourth day, when its progress became so alarming that he permitted it to be destroyed; but it was a month before he recovered. Experiments to determine its contagious nature were also instituted by Dupin, Richeraud, Dupuytren, and Willaume, all of whom decided adversely, while Pointe, Danillo, Clerc, Vautier, and Delpech stoutly maintained the affirmative of the proposition.

Hutchison, in his "Surgical Observations,"** published in 1826, gives a large

* Annales de Littérature Médicale Etrangère et Nationale, vol. xix., Nos. 106 and 107, 1815.
† Mémoire sur la Pourriture d'Hôpital, 1815.
‡ Dissertation sur la Complication des Plaies et des Ulcères, Paris, 1815.
§ Observations on Phagedæna Gangrænosa, Edinburgh, 1818.
‖ Dissert. Med. Inaug de Phagedæna, page 4.
¶ Traité des Typh. Traumat. Gangr. ou Pourriture d'Hôpital, Paris, 1822.
** Practical Observations on Surgery, 1826, page 194.

number of reports from surgeons in the Royal Navy, showing the effect of hygienic measures upon the disease, and, in addition, the Report of Portal and Deschamps to the Royal Institute of France upon the Memoir of Delpech on Pourriture d'Hôpital, in which they entirely approve of his conclusions.

In 1826, and again in 1848, John Boggie,* surgeon to His Majesty's forces in the Peninsular War of 1813, published his "Observations on Hospital Mortification made at the Ropewalk Hospital, Bilboa." The treatment at first had been stimulating, and the result was the loss of 83 out of 1294 cases. Dissatisfied at such a mortality, he adopted the antiphlogistic treatment, bleeding largely, even to the extent of three pounds in some cases, exhibiting cathartics and emetics, avoiding opium and wine, and enforcing a diet of tea, gruel, and farinaceous food. By this plan he alleges that he reduced the mortality to 25 in the next 857 cases, or 1 in 34; and after he had succeeded in getting this treatment well established, a further reduction in the death-rate was attained,—that is, in 796 cases only 6 died, or 1 in 131. Boggie makes two varieties, the "sloughing" and the "phagedænic." He regarded the disease as constitutional, communicated both by contact and through the air, and he says he never saw wounds made by the lancet or scarificator attacked. When the destructive process was rapid, he applied the cautery or acids.

Guthrie† thought the disease contagious and infectious. Out of 1614 cases at Santander, Bilboa, Vitoria, and Passages, 512 died in five months. He gives an extensive summary of the subject, and, on the whole, favors the treatment of Boggie.

Wright‡ records an outbreak of the disease in the Baltimore Almshouse in 1830 and 1831, in which 20 died.

South, in Chelius's Surgery, states that Arnott saw it in the Middlesex Hospital in 1835, and also at the Westminster and York Hospitals, Chelsea.

Samuel Cooper,§ in speaking of this mortification, refers to the declaration of Lisfranc, that hospital gangrene is now a mere trifle, and that by the use of the actual cautery it is entirely under the power of the surgeon.

Hawkins‖ was an advocate for strong acids as a local measure, and says he never saw a death from the disease.

Coote¶ records its appearance at St. Bartholomew's Hospital, and also at St. George's and other institutions, during the autumn and winter of 1846–47. The cases all recovered under hygienic changes and the local employment of nitric acid. The disorder had never been known in these hospitals before, and was thought to be due to atmospheric conditions. In Holmes's Surgery,** this same author says the disease, in 1846, was in two instances traceable to a sponge which, although boiled, had yet retained contagion. He also gives the history of a woman residing in an unhealthy part of London, whose breast had been removed, and in whom the wound was afterwards attacked by this disease. Two persons sleeping in the room which she had occupied were attacked with fever and diarrhœa, and he thinks that, had they possessed open wounds, both would have suffered from mortification.

Fabian,†† in 1848, recommended a French compound, the "citron comme topique," as being possessed of considerable value.

Velpeau,‡‡ in treating upon the subject, expresses his belief in its contagiousness and also in its animalcular origin.

In 1848, Walker,§§ surgeon at Barcena Hospital, Bilboa, from September, 1813, to January, 1814, says that the character of the disease changed at the

* Medico-Chirurgical Transactions, Edinburgh, 1826; also, Observations on Hospital Gangrene, London and Edinburgh, 1848.

† Commentaries on the Surgery of the Peninsular War, 5th edition, 1853, London, page 155; also Lancet, 1848, vol. ii. pages 628, 685.

‡ American Journal of the Medical Sciences, vol. x.

§ Medical Times, August 28, 1847, page 524.

‖ Medical Gazette, June 11, 1847, pages 1024, 1030.

¶ Lancet, 1847, vol. i. pages 374, 405, 515.

** Holmes's Surgery, 1869, vol. i. page 163.

†† Malgaigne's Revue Méd.-Chirurg., October, 1848, page 207.

‡‡ Ranking's Abstract, 1848, vol. viii. page 130.

§§ Lancet, 1848, vol. ii. page 688.

approach of winter, becoming more inflammatory, and yielding to the antiphlogistic treatment of Boggie. Under the stimulating plan more than one in three died.

Tice* saw the disease at Coimbra, where several of his nurses suffered from attacks contracted by dressing the sores of those affected. He notices particularly the extreme depression or despondency which affected the sufferers, and considers it pathognomonic of the approach of the disease. He regards it as a constitutional disease. Boutflower entertained the same views.

Professor Restelle,† surgeon-in-chief of the Sardinian army, saw 400 cases at Alessandria in 1848 and 1849, and believed that, if proper precautions are observed, stumps may be protected against attacks. Caustic potash was his favorite local application. He succeeded in inoculating healthy wounds with the virus, and thought that the disease was the result of some local influence on sores, assisted, no doubt, by a vitiated atmosphere.

In 1860, Parke,‡ a surgeon in the Russian military service during the Crimean War, gives a description of the lamentable condition of the hospitals at Simpheropol. Patients were massed together without classification; those with typhus fever and those with surgical injuries were in the same wards, which were so defective in ventilation and cleanliness that the surgeons would suffer from headache after an hour's exposure to the vitiated atmosphere. The mortality cannot be accurately ascertained, but it was doubtless very great, as at Simpheropol the average number of patients was 15,000 and the average deaths were 133 from typhus and mortification. Parke bestows high encomiums on creasote.

The report of the committee to Parliament on the Medical and Surgical History of the British Army in Turkey and the Crimea in 1858 attributes the outbreak to filthy and badly-ventilated hospitals with insufficient accommodations.

Taylor,§ surgeon to the 29th Regiment of Her Majesty's forces, India, expresses the opinion that the disease as it appeared at Ferozepore was local and not constitutional; the wounds which appeared most prone to take on the disease were those inflicted by grape and canister-shot; and he says that nitric acid gave the most relief from the gnawing and burning pain.

Some idea of the terrible fatality of the disorder may be obtained from the statement of Lallour,‖ surgeon to the French transport-ship Euphrate, that during a single passage of that vessel to the Bosphorus, requiring but thirty-eight hours, sixty bodies were thrown overboard. The mortification attacked all wounds, and even cicatrices. The actual cautery was attended with good effect.

Macleod,¶ in speaking of the cause of the disease, thinks that something different from bad accommodations and filthiness is necessary to explain its appearance. The wounded men who lay thickly around the foul latrines suffered no more than those in other localities. It broke out immediately after a sirocco which prevailed at the time, and manifested no preference for any particular class of wounds, wounds of entrance and wounds of exit suffering alike. The men prone to scurvy were the most favorable subjects. In his experience nitric acid exercised the most decided control in arresting the process of destruction.

Surdun** found iodine, applied externally, to act well, and gives seven cases of amputation in soldiers on shipboard, all of whom were attacked, and all recovered.

* Lancet, 1848, vol. ii. pages 630, 631, 685.
† British and Foreign Medico-Chirurgical Review, October, 1850, page 545.
‡ American Journal of the Medical Sciences, April, 1860, page 570.
§ Macleod's Surgery of the Crimean War.
‖ Ibid.
¶ Notes on the Surgery of the War in the Crimea, London, 1858; also Edinburgh Medical Journal, 1855–56.
** Gazette Hebdomadaire de Médecine et Chirurgie, January 12, 1857.

Groh* gives a record of 59 cases, of whom 7 died. His treatment consisted in ventilation, fumigation, stimulants, chloride of calcium, and mineral acids.

Dr. Joseph Jones,† who saw much of the disease in Southern hospitals among Confederate soldiers, wrote a very exhaustive treatise on hospital gangrene. He believed that neither contact nor abrasion is necessary for its production. He could never trace any connection between the disease and scurvy, but thought the affection was due to some organic poison acting as a ferment. Soldiers who were well fed recovered most rapidly, so that the Union troops suffered less than the Confederates. Out of 385 cases at Empire Hospital, Georgia, one-quarter died. In the Army of the Tennessee there were, during July and August, 1864, 344 cases, with 26 deaths, or, including September and October, nearly 3000 cases, one-half of whom were disabled for the war. Fresh air, ventilation, change of locality, and the local use of nitric acid constituted the plan of treatment.

Jüngken,‡ who saw the disease in the Charité Hospital and also at Dresden, decided that there is no specific save cleanliness and removal into the open air under a tent-roof: without these the cautery is of little use, as the gangrene will return after the slough is detached.

Hutchison § tried treatment by submersion with alleged good success, the cases cleaning off in three days, and in ten days healing rapidly.

In 1863 a number of papers appeared on this subject, amounting, as far as I can learn, to nineteen.

North ‖ gives 60 cases at the United States Army Hospital at Frederick, in the fall of 1862, with 3 deaths. In only 7 cases were there any constitutional symptoms present. Nearly all the nurses who had any wounds suffered.

Browne,¶ in speaking of the mortification as it was seen at the Marine Hospital at New Orleans, states that no foreign organisms or fungoid growths were discovered in the sloughs.

Brinton,** in his "Report to the Surgeon-General on the Condition of the Louisville Military Hospital," says that the disease showed little tendency to spread from bed to bed, although isolation was not enforced. Out of 88 cases there were only 2 deaths, and these suffered from other complications. Bromine was his favorite local application, it being injected hypodermically at the margins of the disease. Dr. Brinton believes in the local nature of the disorder.

Hinkle,†† A.A.S., U.S.A., saw the disease at the Campbell and Jervis Hospitals, Baltimore, and at the Armory Square Hospital, Washington. The permanganate of potash was his favorite remedy, internally and externally. Peters reports cases from the same hospitals. Lloyd,‡‡ Stanford,§§ and Doherty ‖‖ all bear testimony to the value of bromine, when applied pure.

To M. Goldsmith,¶¶ Surgeon U.S.V., the profession is indebted for the use of bromine in hospital mortification. His observations were made at New Albany, Nashville, Murfreesboro', and Louisville. In drawing the comparison between bromine and nitric acid, he gives 152 cases treated with the first, with only 4 deaths, all of which were complicated; and 13 cases with the

* Groh on Hospital Gangrene, Wien. Med. Zeitschr., 1858, pages 35, 38; Schmidt's Jahrbücher, No. v. vol. cvi. page 198.

† Jones, Investigations on the Nature and Causes and Treatment of Hospital Gangrene, United States Sanitary Commission, Surgical Memoirs, vol. ii., 1871: also New Orleans Medical Journal, January and April, 1869.

‡ Allgemeine Med. Centralzeit., xxx. 67; Medical Times and Gazette, Nov. 2, 1861.

§ Hutchison, Medical Times and Gazette, 1862, vol. i. page 8.

‖ American Medical Times, 1863, vol. i. page 255.

¶ Ibid., May 2, 1863, page 215; also Proceedings of the New York State Medical Society, 1863–64.

** American Medical Times, May 23, 1863, page 250; also American Journal of the Medical Sciences, July, 1863, page 279.

†† American Medical Times, November 28, 1863, page 254.

‡‡ Ibid., November 28, 1863.

§§ Ibid., 1863, vol. ii. page 24.

‖‖ Ibid., August 22, 1863, page 84.

¶¶ Ibid., September 12, 1863, page 121; also Report on Hospital Gangrene, Pyæmia, etc., Louisville, 1863.

last, with 8 deaths. Of 13 other patients, in whom various remedies were used, 5 died. Dr. Goldsmith believes it to be a local disease.

Detmold,* in his "Lectures on Military Surgery," asserts his belief in the local nature of hospital mortification. He thinks it may arise from the presence of some microscopic fungus; he does not believe it ever attacks an unbroken surface; and he says that it may be introduced into the best-policed hospital by patients or by infected clothing.

Weeks† furnishes the record of 115 cases, in Louisville, 104 of which were treated with bromine and 11 by other remedies. Of the 104 only 3 died,—2 by pyæmia and 1 by cellulitis; of the 11, 3 also died. He regards the affection as a local one, and believes that the materies morbi enters by the wound and not by the lungs, and that the constitutional symptoms are secondary. He has frequently seen cases of embolism of the lungs and other parts of the body following the disease. Laurence‡ is also a localist, esteeming the constitutional symptoms, when present, as secondary.

Radcliffe,§ A.A.S., U.S.A., saw the disease among the prisoners who had been brought from Richmond to the United States General Hospital at Annapolis. He relied on nitric acid and stimulants for its treatment.

Woodward,‖ Surgeon U.S.A., and the medical historian of the war, instituted observations at all stages of the disease, to determine the question of a cryptogamic origin, and, after using the highest powers, failed to discover any microscopic organisms except vibriones, which are met with in all decomposing animal substances.

Hamilton,¶ though he does not advocate the constitutional origin of the disease, states that he saw two cases of hospital gangrene without any previous wound, in one of which the soft tissues were destroyed over nearly the entire length of the tibia. The number of cases which he had under observation at the McDougal Hospital was 36. Of this number, 18 were treated by nitric acid, the average duration of the treatment extending over sixteen days; 14 were treated with bromine, their average duration being twelve days; and 1 with iodine, recovery taking place in seven days.

Parker** thinks the causes of hospital gangrene identical with those of typhus, with the addition of a suppurating wound.

Ball†† saw 43 cases, under the care of Weir, at Frederick, and says that when the wind blew from the tents towards the hospital in which were placed the gangrenous cases, new cases would appear in the latter; but when the current of air was in the opposite direction, no new ones arose. He also states that when the door was left open into the gangrenous ward, patients occupying the beds nearest the door were first attacked.

Post‡‡ witnessed the disease at Nashville and Louisville Hospitals. This surgeon tied the posterior tibial artery at the bottom of a gangrenous wound, the patient making a good recovery. His treatment was by stimulants and bromine. Moses§§ also relied on bromine, one application in his hands usually proving sufficient. He regarded the disorder as purely a local one.

Alley‖‖ was also an advocate for the use of bromine. Pittino's¶¶ article on the subject relates to the cases at Annapolis from Libby Prison. Crane*** treated three cases with chlorinated washes.

* American Medical Times, Feb. 21, 1863, page 97.
† Ibid., 1863, vol. ii. page 46.
‡ Laurence's Lectures on Surgery, page 197.
§ American Medical Times, April 4, 1863, pages 161, 172.
‖ Ibid., April 11, 1863; and Report to the Surgeon-General.
¶ Ibid., 1863, vol. ii. pages 181, 205.
** Ibid., Sept. 5, 1863, page 109.
†† Ibid.
‡‡ Ibid., Sept. 12, 1863, page 122.
§§ American Journal of the Medical Sciences, vol. xlvii. page 331.
‖‖ Buffalo Medical Journal, Sept. 1863.
¶¶ American Journal of the Medical Sciences, July, 1863, page 50.
*** Ibid., page 56.

In 1864, Pick,* at St. George's Hospital, London, dissatisfied with nitric and carbolic acids, passed a stream of chlorine gas through the affected ward, and found the disease completely arrested in four cases. In his opinion opium was omnipotent. Under the use of this remedy, in 47 cases, the disease was subdued in forty-eight hours, and in a smaller number, in one day.

In 1864, also, an article was published by Bartholow† on this form of mortification; one by Pryer,‡ in which, besides recognizing two forms of the disease, he advocates the use of pyroligneous acid as a local remedy; and one by Hackenberg,§ in which turpentine is highly extolled.

Mr. Maunder|| believes that the disease may arise from a vitiated atmosphere, entirely independent of a specific materies morbi, and also that it may be introduced into a hospital from without. He is an advocate of nitric acid and a water-dressing.

Packard¶ recommended the use of a hydro-carbon as a local dressing. He sprinkled or poured over the parts white sugar or thick syrup, and covered the ulcer with lint. He believes the disease to be a local one.

Le Conte suggested the free use of powdered charcoal, chiefly to deodorize the foul slough.

Atlee,** in a review of Dr. Goldsmith's book on hospital gangrene, says that patients get well in spite of bromine, not by it; he thinks the infection is received both by open wounds and through the lungs; and he extols the external application of buttermilk, as practiced by Pfeiffer at the Satterlee Hospital.

Kempster†† believed strongly in the constitutional origin of the disease, general symptoms being prominent in the cases which he witnessed at the Patterson Park Hospital, Baltimore, in 1864.

Herr‡‡ saw the disease at Hospital No. 1, Nashville, in 1864, where 14 deaths occurred in 202 cases. With him bromine ranked first, and chloride of zinc next, as local remedies. At the same time 300 were treated at the Cumberland Hospital with nitric acid, of whom 50 died.

Thomson§§ made numerous microscopical examinations at the Douglas Hospital, but without discovering any organisms which could be charged with an infective influence. He cautions against over-stimulation, and gives cases in which bromine succeeded in curing the disease after nitric acid had failed.

Lane|||| advocates the continuous use of dilute nitric acid.

Bligh¶¶ tried both nitric acid and bromine in the War of the Rebellion, and decided in favor of the last.

Smart,*** Inspector-General of Hospitals of the Royal Navy, uses carbolic acid as a preventive, and permanganate of potash as a curative agent. For obstinate or aggravated cases he believes the chloride of zinc and the actual cautery to be among the most valuable agents. In 1857 and 1859 he witnessed the disease at Hong-Kong. He considers it a low inflammatory action of zymotic origin, the microzymes being in the atmosphere or adherent to dressings. Fresh air, he thinks, without remedies, will cure the disease.

Miller,††† at the 17th Corps Hospital, Atlanta, Georgia, could not procure bromine, but used, with excellent effect, a saturated solution of iodine.

* British Medical Journal, 1864, vol. i. page 262.

† American Journal of the Medical Sciences, March 5, 1864, and Jan. 1865, page 274; also Cincinnati Lancet and Observer, Oct. 1864.

‡ American Medical Times, 1864, vol. i. page 4.

§ Ibid., Nov. 28, 1864, page 264.

|| Clinical Lectures and Reports, London Hospital, 1864, page 104; also Braithwaite's Retrospect, vol. l. page 215.

¶ American Journal of the Medical Sciences, Jan. 1865, page 114.

** Ibid., Jan. 1864; also, July, 1865, page 61.

†† Ibid., April, 1866.

‡‡ Ibid., Jan. 1867, page 281; also Nashville Medical Journal, Aug. 1866.

§§ American Journal of the Medical Sciences, vol. xlvii. page 393.

|||| Medical Times and Gazette, March 30, 1867.

¶¶ Lancet, Aug. 29, 1868, page 278.

*** Ibid., Oct. 1, 1870.

††† American Journal of the Medical Sciences, Oct. 1871, page 462.

Professor Spence* insists in his lectures that the open air is the only proper place for this class of cases. If it is attempted to treat them in the wards of a hospital the success will depend on the multiplied contrivances for ventilation and cleanliness.

Bryant† saw the disease at Guy's Hospital, London, in 1849, when contused as well as open wounds were attacked. He thinks the ulcerative form is preceded by constitutional symptoms, the sloughing form always by local signs; and he interdicts entirely the use of sponges.

Treibes‡ regards the affection as a *diphtherite*, in the first instance, purely local, and uses electricity.

Billroth§ ventures the opinion that the epidemic prevalence of this kind of mortification may be due to minute organisms of rare occurrence.

Von Pitha and Fock|| regard the disease as an epidemic, and as miasmatic in origin.

Heiberg¶ had an opportunity of seeing all the cases at Berlin, in the Franco-Prussian War. The temperature-curves, being very irregular, revealed no special type of the disease. Low diet and ice-water formed the internal treatment, and chloride of zinc well worked into the incisions, with subsequent dressings of oil, the local management of the sores.

* Lectures on Surgery, Edinburgh, 1871, page 67.
† Bryant's Practice of Surgery, London, 1872, page 447.
‡ Lancet, Nov. 2, 1874, page 646.
§ Billroth's Surgical Pathology, American ed., 1875, page 322.
|| Ibid.
¶ Virchow's Archives, liii.

CHAPTER II.

WOUNDS.

General Considerations.—A wound is a solution of continuity in any tissue or organ, produced by direct or indirect violence. The infliction of a wound is followed by hemorrhage, pain, and retraction of tissue.

Wounds are most conveniently classified according to the nature of the vulnerating body by which they are produced.

There are six varieties,—incised, lacerated, contused, punctured, poisoned, and gunshot wounds.

The indications in the treatment of wounds are, the *arrest of hemorrhage*, the *removal of foreign bodies*, the *proper apposition of the divided parts*, and the *use of such measures as will co-operate with nature to the fullest extent in the repair of the damage.*

Hemorrhage.—There is no sight so appalling and sickening as a formidable hemorrhage. The sight of even a few drops of blood will often, with many persons, produce fainting. Scenes of this kind are quite common at the opening of every session in the operating amphitheatres. Abhorrence of blood is most wisely implanted in our humanity, and exhibits the value set by God on human life. Except on the battle-field, in street-fights, or assassinations, death from hemorrhage is not common; and with the resources at our command (the wounded vessel being outside of the trunk) the surgeon who allows a patient to perish before his eyes, save in exceptional cases, may well question his fitness for the responsible work in which he is engaged.

When a large artery is opened by disease, accident, or incompetency, the blood gushes out with a bound, in a red, angry stream, and if not immediately checked the face grows pale, the color leaves the lips, and the patient, in consequence of the rapid diversion of blood from the brain, falls into a state of syncope. Here we have a beautiful illustration of that provision which exists in the organization, by which life, even in the direst extremity, is conserved. The rapid depletion of the brain and spinal marrow deprives the heart of its motor-power, and so weakens its stroke that the blood moves slowly and feebly, scarcely reaching the smaller vessels, thus allowing time for the formation of a clot at the bleeding orifice. After a time the heart begins to recover its strength; the blood is impelled with more vigor; it reaches the extremities and surface of the body; the pulse at the wrist can be felt, the color returns to the lips, the warmth to the body, and now the stream becomes forcible enough to dislodge the protecting clot. The bleeding is renewed with an impetuosity little less than at first, when again the deadly yet friendly syncope intervenes to stay, for a time, the work of destruction. At each repetition of such a scene the symptoms prove more urgent: the face assumes a deathly pallor, appearing transparent, puffy, and wax-like; the lips become bluish; the pulse feeble, less frequent, and, finally, imperceptible. The temperature falls first at the extremities, and progressively over the body, the surface of which is covered with a cold, clammy perspiration. If the patient attempts to rise, he is seized with dizziness; objects become indistinct and vanish into the darkness; the pupils are widely dilated; the mind becomes confused; the stomach sickens; the ears are filled with strange sounds, and everything seems to whirl; the thirst is insatiate;

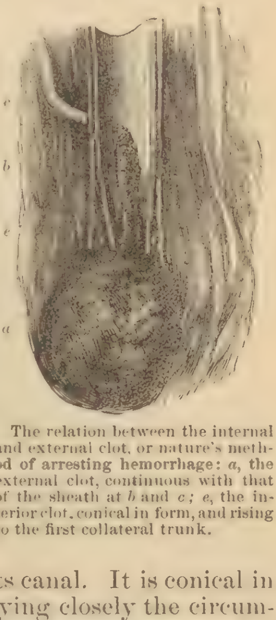
there is an uncontrollable restlessness, and a sense of suffocation; the arms are thrown over the head, as if to grasp something by which the muscles on the exterior of the chest might aid in the work of respiration; the breathing is carried on in sighs and gasps; there is an entire absence of pain, and the countenance wears a frightened and anxious expression. The patient struggles to rise, but as often falls back in a faint, no longer able to hold out in the unequal conflict; the respiration becomes more feeble, the eyes glazed and motionless, with occasional muscular twitchings of the face and extremities, until at last the sufferer sinks into a state of unconsciousness, and death quietly claims his victim. How forcibly has the sculptor impressed upon his marble, in the attitude of the Dying Gladiator, a truthful representation of a man whose life is slowly ebbing away from hemorrhage!

To control hemorrhage permanently the vessel must be closed by an organized structure, the result of inflammatory action. In small vessels, and sometimes in those even of the size of the radial, nature may accomplish the work without any assistance from the surgeon. I shall first explain her method. When a wound is inflicted by a sharp-edged instrument, involving vessels of moderate size, there will be a sudden and profuse gush of blood. After a short time it diminishes, and finally ceases altogether, or amounts only to an oozing. How is this process accomplished?

The vessels, the blood, and the perivascular tissues are all concerned in the work of hæmostasis. When an artery is divided, it contracts within its sheath, and the fibres of connective tissue or other contiguous structures sink across its extremity, often concealing it from view, and requiring, for its exposure, that it shall be drawn out of its hiding-place. Not only does the artery retract, but it also contracts to its flattened or ovoidal form, thereby diminishing its canal, and thus offering a mechanical resistance to the escape of the blood. If a large amount of blood is lost, the heart's action will be weakened, in consequence of which the column of blood is propelled with diminished force against the walls of the vessels. We frequently see, after a sudden and exhausting hemorrhage, the injured vessel lying in the wound, collapsed, and without exhibiting the least sign of pulsation. It is because the wave of blood has not sufficient momentum imparted to it by the heart to reach the divided artery.

What part does the blood play? This fluid possesses the property of coagulation, forming what are called clots, or thrombi. The moment it escapes from the vessels it usually undergoes this change, which is favored by mechanical points of obstruction. If a little irregularity forms on the inner side of an artery or vein, or if a fine thread is stretched across the lumen of a vessel, very soon there will be an embolism or thrombus induced. As soon as the flow slackens the blood begins to coagulate. The straggling fibres of the sheath of the vessel or contiguous muscles at its orifice play the part of the threads just described,—that is, serve as a net to entangle the fibrin,—so that a clot accumulates at the end of the artery and around it, extending up its canal as high as the first chief collateral branch (Fig. 71); and the same occurs in the other, or distal, portion of the wounded trunk. We have now a plug which, in its relation to the vessel, resembles somewhat the glass stopper of an old-fashioned decanter. The portion of the clot or thrombus within the artery does not accurately fill its canal. It is conical in form, the apex directed upwards, and the base occupying closely the circumference of the arterial orifice. After a time, however, the clot increases by

FIG. 71.

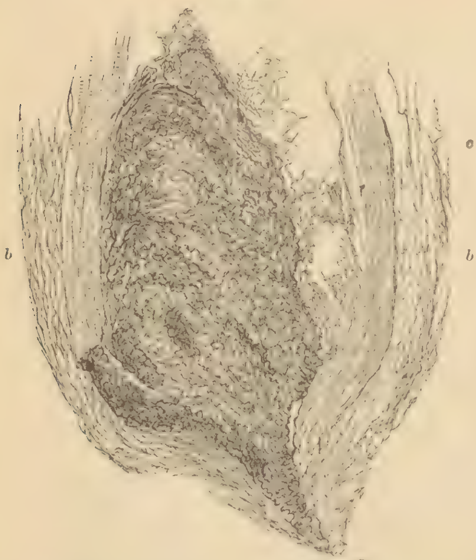


The relation between the internal and external clot, or nature's method of arresting hemorrhage: *a*, the external clot, continuous with that of the sheath at *b* and *c*; *e*, the interior clot, conical in form, and rising to the first collateral trunk.

attracting to itself a new deposition of fibrin until it more perfectly occupies the lumen of the vessel. So far the thrombus is not of a permanent kind, and is liable to become displaced by a column of blood impelled by the recovered power of the heart, producing a renewal of the hemorrhage.

To make such closure secure against all contingencies there must be a vital union between the thrombus and the walls by which it is surrounded; and this brings me to the permanent closure of vessels. In order to study this process satisfactorily, I had a number of ligations made of the arteries of dogs, by Dr. William H. Mastin, one of the resident physicians of the University Hospital. The animals were killed at different periods, and carefully injected, after which I had an opportunity of studying each specimen as it was prepared by one of our most eminent microscopists, Dr. E. O. Shakespeare. These experiments, if they were properly interpreted, establish the fact of the transformation of the coagulum, clot, or thrombus into an organized structure, and its unification with the walls of the vessel.

Fig. 72.



A longitudinal section of the crural artery of a dog twenty-four hours after ligation, magnified 60 diameters: *a*, constricted point, or seat of ligation; *b*, *b*, walls of vessel; *c*, clot or thrombus, with its transverse or laminated striation and conical form.

When a ligature is placed about an artery and firmly tied, the vessel is constricted and puckered up at the point of application. The effect of such constriction is to divide the middle and internal coats, which become both incurved and retracted, the external or fibrous coat remaining unsevered. The blood thus arrested begins to coagulate first at the seat of ligation, where it occupies the entire circumference of the canal of the vessel. To this coagulum or thrombus are added successive layers or laminæ, and as the column rises it becomes conical in form, reaching up to the first collateral branch, and either not touching the walls of the vessel or resting only against one of its sides. (Fig. 72.) The direction of these successive additions or laminæ in the thrombus is transverse or slightly oblique.

Fig. 73.

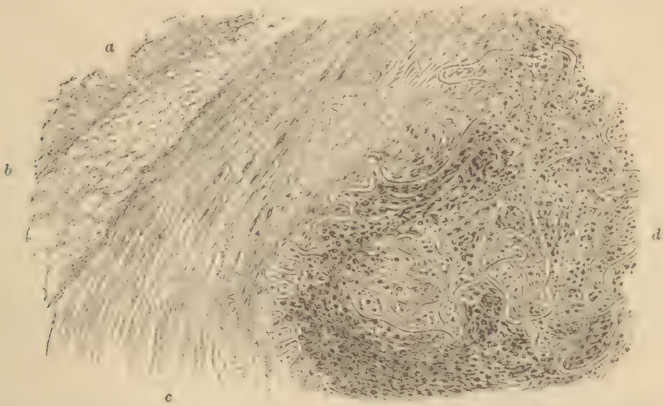
Longitudinal section, showing the clot in the crural artery of a dog twenty-four hours after ligature, magnified 225 diameters. The dark points indicate the white corpuscles, all the other points the red corpuscles.

If a portion of this internal thrombus be examined, at any time after its coagulation, with a sufficient power, it will be seen to consist of a vast crowd of red corpuscles, with here and there, indiscriminately scattered, a few white ones, and all supported in the fibrinous frame-work of the clot. (Fig. 73.)

Pressing the investigation further, let a section of the artery and its clot be

made twenty-four hours after ligature, and a wonderful change will be noticed in the numerical relation of the two kinds of corpuscles. Even in this short period of time the red, which had predominated so greatly, have begun to disappear, and the white corpuscles are now seen thickly scattered over the field. If successive sections of this clot be made from the base towards the summit, it will be seen that the white corpuscles diminish in numbers from below upwards; that is, they are most numerous in the oldest part of the clot. The secure manner in which the clot or thrombus is first mechanically connected with the inclosing walls of the vessel is here worthy of observation. This connection is threefold: first, by being crowded into the corrugations made by the puckering of the vessel at the place of ligature; second, by moulding its surface into the plications of the tunica intima, or internal coat; and last, by the peculiar behavior of this coat, which, after being severed by the ligature, splits into filaments or threads, which float into the midst of the coagulating blood, and, like guys, serve to moor the clot securely in place. (Fig. 74.) The questions which at this stage of the process demand explanation are very difficult of solution. We are not yet in a position to answer

FIG. 74.



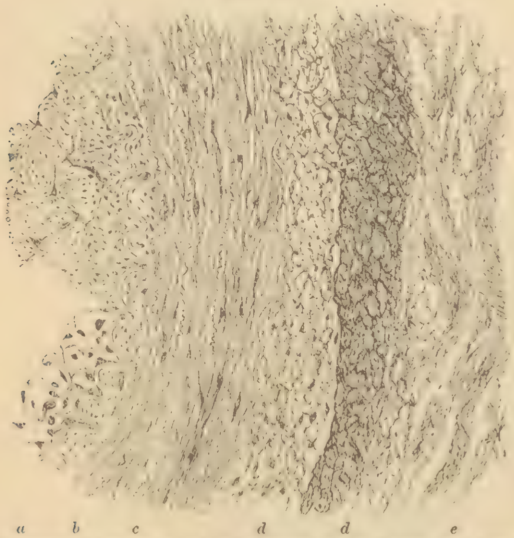
Transverse section of the crural artery of a dog through the base of the clot forty-six hours after ligature, magnified 225 diameters: *a*, adventitious and fibrous tunic; *b*, tunica media; *c*, plications of the tunica intima, or internal coat; *d*, the clot filling up the foldings of the internal coat, with the threads of the intima winding like the tendrils of a vine in its midst. The dark bodies are the white corpuscles, now very numerous.

them with any certainty, and any attempt in that direction brings us at once into the domain of conjecture. These questions are, Where do these crowds of white corpuscles come from? and what is the destiny of the red globules? With reference to the first, the origin of the white bodies, several explanations may be advanced. They may originate by proliferation from the few which naturally belong to the thrombus, as no limit can be fixed to the rapidity of cell multiplication under certain stimulation; they may be emigrants wandering into the clot from the vasa vasorum, according to the views of Recklinghausen and Bubnoff; they may be derived from the stable cells of the tunica intima, which accords with the opinions of Romberg and Thiersch; and last, and least probable, they may be but a retrograde metamorphosis of the red corpuscles, on the supposition that the red are developed from the white corpuscles. I cannot, however, help believing that these cells are derived from three sources: first, from the proliferating white corpuscles of the clot; second, from the fixed corpuscles of the endothelium; and last, from the emigrants from the vasa vasorum. It is quite as probable that the endothelial cells should participate in the work of repair, in other words, change from a passive to an active state, as that those of connective tissue should do so under the disturbing influence of inflammation. Those experiments which show the presence of cells in new formations bearing granules

of cinnabar previously injected into the blood, would seem to establish a claim for emigration. This last view is not in accord with that of Billroth, who denies to the stable cells of the intima any participation in the work whatever, attributing the multiplication of white corpuscles to the leucocytes of the clot, and to wanderers from the neighboring vessels, coinciding in this respect with the statements of Recklinghausen and Bubnoff. As to the red corpuscles, they very soon become decolorized by the separation of crystals of hæmatoidin, and, it is supposed by some, form an intercellular substance by uniting with the fibrin of the thrombus.

If the thrombus be examined on the fifth day, another notable change will be seen. Many of the cells have become spindle-shaped,—one step in the direction of forming connective tissue; others have sent out prolongations, which, joining with similar processes from contiguous cells, form together a net-work with very distinct nuclei at the points of contact or communication. In this system of inosculating processes we have the provision for the vascularization of the thrombus. These processes become blood-channels (Fig. 75), and, although as yet containing no blood, they are, like the irrigating canals which are cut in various directions through some arid waste, designed to receive the streams which are to give life and fruitage. While these changes are in operation within the thrombus, the walls of the vessel are by no means passive. An active inflammatory transudation is going on, infiltrating its tunics, and extending even into the loose cellular tissue of the adventitious coats. It is this which rives asunder the fibres, lamellæ, and fasciculi of the arterial tunics, and admits of their being interpenetrated by cell organisms or leucocytes, which wander out of the nutrient vessels, and which, like those of the clot within, assume the spindle forms, which are the promise of the future connective tissue.

Fig. 75.



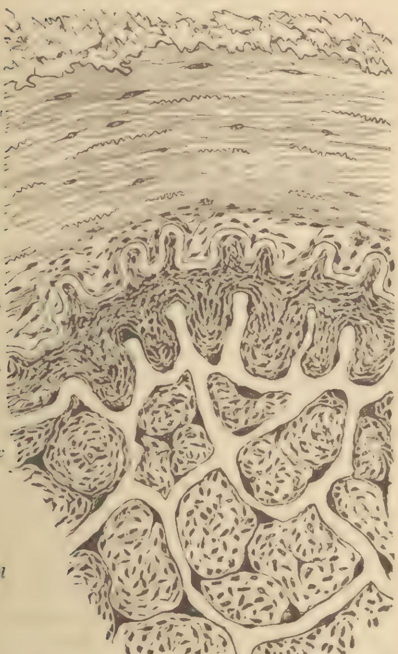
A transverse section of the crural artery of a dog four days after ligature, magnified 225 diameters: *a*, thrombus or clot, bounded by the plication of the tunica intima, its cells spindle-shaped, the network of branching processes, with the nuclei at their intersection, foreshadowing the subsequent vessels in a state of formation; *b*, clot torn away, and showing proliferating endothelial cells adhering to the intima: *c*, cell infiltration of the tunica media; *d*, *d*, and *e*, similar infiltration of the external tunica and perivascular tissue.

In the course of eight days the work foreshadowed in the thrombus of five days is well advanced. Many of the blood-channels are completed, and others are in process of completion, the processes of the latter connecting with the nuclei on the walls of the former; the spindle form of the cells, both of the clot and walls, is more pronounced, and near to the intima they have reached the stage of immature connective tissue. (Fig. 76.) The clot is beginning to shrink, from loss of moisture in the intercellular substance, the whole becoming more compact. In all these changes or stages of transformation it would appear that the constructive force develops out of the materials of the original clot an organized tissue,—that is to say, the white cells of the thrombus retain their vitality and undergo multiplication, passing on to spindle forms; that the fibrin which determines the coagulation is not substituted by something else, but transformed into intercellular material, the fibrillation of which, with the spindle-cells, constitutes true connective

tissue; and, finally, that from other cells a system of inosculating canals is constructed, thus forming a vascularized structure.

Thus far we have traced the leading changes in the clot towards organization. We have seen the infiltration of the tunics of the vessel with cell forms, similar to those in the coagulum, and their intermingling at the tunica intima, obliterating in some degree their distinction from the latter. It still remains to establish a very important vital connection between the two, and that is the connection or inosculation of blood-vessels. The thrombus is in possession of a system of capillaries, but they contain no blood; and the next step is to form such a union with the vessels of the artery as will establish not only a unity of blood-channels, but also a oneness of circulation. To accomplish this it would appear, from certain preparations recently made by Dr. Shakespeare illustrative of this point, and which I had the opportunity of examining, that in this inosculation between the vessels of the thrombus and those of the walls the former take the initiative, penetrating the tunica intima, first, near to the point where the artery has sustained the greatest injury by the action of the ligature. (Fig. 77.)

FIG. 76.



A transverse section of the femoral artery of a dog eight days after ligature, magnified 400 diameters: *a*, tunica media; *b*, intima; *c*, capillary channels, with branching processes communicating with nuclei in the walls of the capillaries; *d*, spindle-cells; *e*, similar cells developed into connective tissue and forming communication with those of the intima.

FIG. 77.

An injected longitudinal section of the crural artery of a dog, twenty days after ligature, magnified 60 diameters: showing the vessels of the organized clot, the vessels of the walls, and their inosculation.

Treatment of Hemorrhage from Wounds.—The means for arresting bleeding are very numerous, and are called hæmostatics. They may be divided into *Vital*, *Chemico-vital*, and *Mechanical*.

VITAL HÆMOSTATICS are such as induce contraction of the muscular fibres of the vessels by acting upon their physiological irritability: they may operate either locally or through the constitution.

External or Local Vital Hæmostatics.—The most potent agents of this class are the following:

Cold.—The exposure of a wound to the atmospheric air will secure the contraction of small vessels, and even those of considerable size are sensibly affected by its presence. John Hunter saw the carotid artery of an ass markedly diminish when opened to the air. The object of the common practice of leaving a wound open for some time is to take advantage of the hæmostatic influence of the atmosphere; and to realize the greatest effect

from its action a fan may be used to maintain a succession of currents. Cold can be applied in the form of water or of ice. If the former, it may be squeezed from the pores of a sponge in a shower over the wound, or be thrown in a steady, fine stream from the nozzle of a syringe: the latter plan exercises a powerful influence in securing the contraction of small vessels. If ice be employed, it should either be broken into pieces and laid directly upon the bleeding surface, as in operations upon the vagina and the cavity of the uterus, or the rectum, or be inclosed in rubber-bags, bladders, or tin boxes, which are to be placed about the bleeding parts.

Alcohol possesses considerable power in exciting the contractility of vessels, and may be employed by moistening a soft sponge with the liquid and pressing it gently upon the bleeding surface.

Turpentine also acts on the vital contractility of the vessels, and may be applied by saturating dossils of lint with the liquid and applying them over the bleeding points.

Internal Vital Hæmostatics.—The principal internal vital hæmostatics are the oil of turpentine, oil of erigeron, ergot, acetate of lead, and aromatic sulphuric acid. The first three possess unquestionable power over the vessels, and may be used with great benefit, especially in pulmonary, uterine, and nasal hemorrhages. Ten to fifteen drops of turpentine may be exhibited in a mucilaginous menstruum every two or three hours until relief is obtained, not forgetting, however, its tendency to produce vesical irritation. The oil of erigeron should be given in the same doses. The best form for administering ergot is the fluid extract: forty drops should be given every half-hour in a little water. In hemorrhages which come from the portal vessels, the result of hepatic pressure, aromatic sulphuric acid often proves of great utility when given in doses of fifteen drops every two or three hours, largely diluted.

THE CHEMICO-VITAL CLASS includes all agents which favor coagulation of the blood and produce contraction of the muscular walls of the vessels. The most important are tannic and gallic acids, alum, matico, the iron salts, nitrate of silver, and chloride of zinc. When carefully examined, it will be found that their effects are also mechanical, as the coagulum which they favor serves the part of a plug to the bleeding orifices of vessels. Among these, alum is the least objectionable. It should be dissolved in warm water and applied when tepid, as it will then be deposited in fine crystals about the vessels. Nitrate of silver sometimes answers a good purpose, particularly in cases of leech-bites which continue to bleed: a crayon may be rubbed down to a point with a few drops of water, and the wounds lightly touched with the solid stick. Of the iron salts, the perchloride, Monsel's solution, and the subsulphate are the most popular. The first two may be used pure, or diluted with three or four parts of water, and applied by saturating a compress with the liquid and placing it upon the surface from which the blood issues; the latter, or subsulphate, should be sprinkled over the point of hemorrhage. Both the perchloride and the subsulphate produce a hard, insoluble coagulum, which is very difficult to detach, and are much used to arrest the bleeding from leech-bites. Except in such cases, I have an abhorrence of the entire class, save perhaps alum and alcohol, since they all interfere both with the apposition and the healing of wounds. The styptic fluid of Pagliari, consisting of benzoic acid and alum, at one time popular on the Continent, and the alcoholic solution of Venetian soap and carbonate of potash, a favorite, I believe, with Professor Joseph Pancoast, are open to the same objection.

MECHANICAL MEANS.—These are position, pressure, actual cautery, galvano-cautery, torsion, acupressure, and the ligature.

Position.—This consists in taking advantage of gravitation so as to diminish the force of the circulation through the vessels in the neighborhood of the wound. The part should be elevated by being placed upon an inclined plane. Any one can test the effect of position on the arterial beat by first elevating the arm over the head and then allowing it to hang by the side, examining

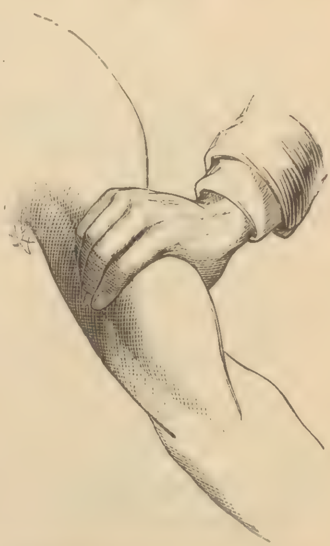
in each instance the radial pulse. It will be found to be much less forcible in the first than in the last position. The same is well seen in the distended and flaccid state of the veins of the hands according as the extremity lies along the side of the body or is elevated.

The position of *extreme flexion*, by which a mechanical obstacle is placed in the way of the circulation by the acute angle formed in the course of the artery, is worthy of notice. This plan was adopted by Mr. Hart in the treatment of aneurism. It is applicable in wounds near the hand or foot, and is effected by forcibly flexing the forearm on the arm, or the leg upon the thigh and the thigh upon the abdomen, and so retaining them by the turns of a roller. The position is a very uncomfortable one, and sometimes becomes intolerable to the patient. The web of the spider, so popular as a domestic remedy, belongs to the mechanical class, and acts simply by entangling the blood and favoring coagulation.

Pressure may be made by the fingers, by compresses, by rollers, the garrot, and the tourniquet.

Digital compression is admirably suited as a temporary method, and also in cases of emergency, for the control of hemorrhage. When the finger can command an artery there is no necessity for alarm. It cannot, however, except by relays, be maintained for any considerable period of time: the fingers become weary and powerless. To be practicable, the vessel must be contiguous to a bone, against which it can be pressed; as, the brachial against the humerus, the radial upon the radius, and the femoral upon the pubic bone. Even the abdominal artery, from its relation to the spinal column, may be placed entirely under the control of the hand. A knowledge of the relation of arteries to the bones of the skeleton will enable an intelligent assistant to render material service to the surgeon while executing an operation: for example, a thumb and finger over the jaw in front of the masseter muscles will command most of the superficial circulation of the face, and in amputation at the shoulder-joint an associate's hands are necessary in the last steps of the operation in order to prevent a dangerous escape of blood, by grasping the axillary vessels.

Fig. 78.



Manner of pressing the brachial artery.

The manner of using the fingers for the purpose under consideration will depend upon the vessel to be compressed. If the circulation through the brachial artery is to be controlled, the fingers should be placed over the vessel, along the inner edge of the biceps muscle, with the thumb on the opposite side of the arm. (Fig. 78.) If the current through the femoral artery is to be restrained, the thumb may be placed upon the vessel as it passes over the pubic bone, while the fingers grasp the outer part of the thigh, or, if lower down, both hands may be used, one thumb being placed upon the other, with the fingers embracing opposite sides of the limb. (Fig. 79.)

If the carotid requires compression, the thumb should be placed at the inner edge of the sterno-cleido-mastoid muscle, opposite the lower edge of the thyroid cartilage, and thrust downwards and inwards, so as to force the vessel away from the vein and against the transverse processes of the cervical vertebræ, the fingers passing across the median line of the neck to the opposite side, but making no counter-pressure. The temporal artery is best obliterated by placing a thumb in front of the ear, above the zygoma, with the fingers resting against the opposite temple.

To make effectual digital compression upon the abdominal aorta, the patient must be in the recumbent position on the back, with the limbs drawn up and the shoulders raised, so as to relax the abdominal parietes; three fingers of one hand should be planted over the vessel, a little to the left of the umbilicus, the thumb reaching out to the flank, while the fingers of the other hand should be placed upon those of the first, in order to supply the necessary degree of pressure.

Fig. 79.

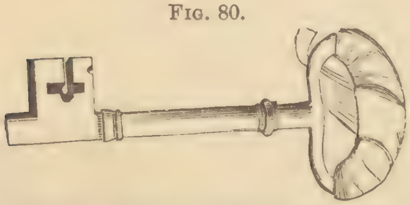
Compression of the femoral artery below Poupart's ligament, with both hands.

When a dangerous flow of blood takes place from an open wound, a finger should be thrust directly into the orifice, down to its lowest depth, where it must remain until measures are taken for the permanent control of the vessel.

Some arteries are so deeply situated that the fingers are insufficient to maintain the requisite pressure,—for example, the subclavian. The best substitute in this case is the common door-key, the handle of which should be wrapped with a narrow roller (Fig. 80) and pressed into the subclavian hollow of the neck immediately above the clavicle.

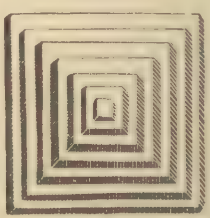
Compresses are often useful. When the vessel is deep they should be graduated or pyramidal in shape (Fig. 81), the apex being placed over the vessel above the wound and firmly bound to the part by a roller. They are sometimes useful in wounds of the palmar arch;

Fig. 80.



Door-key prepared for pressing the subclavian.

Fig. 81.

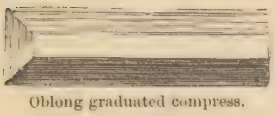


Pyramidal compress.

they may be square, and placed over the approximated wound and secured by a bandage. When the bleeding comes from several points, or where it is a general oozing, the compress is one of our best dressings.

An oblong graduated compress (Fig. 82) serves a valuable purpose in certain wounds,—for example, those of the palmar arch, in which it should be placed over the course of the radial and ulnar arteries and bound fast with a roller. The roller alone, applied from the distal to the proximal extremity of the limb, answers a good purpose in passive hemorrhages.

Fig. 82.



Oblong graduated compress.

When large vessels—as the femoral, radial, or ulnar—are opened, no dependence, except as a temporary measure, should be placed on pressure, nor should it be long continued, as it may interrupt the circulation to such a degree as to produce mortification. In cases where compresses are applied the roller should invariably be used, and should include the entire limb, commencing at the distal and terminating at the proximal extremity.

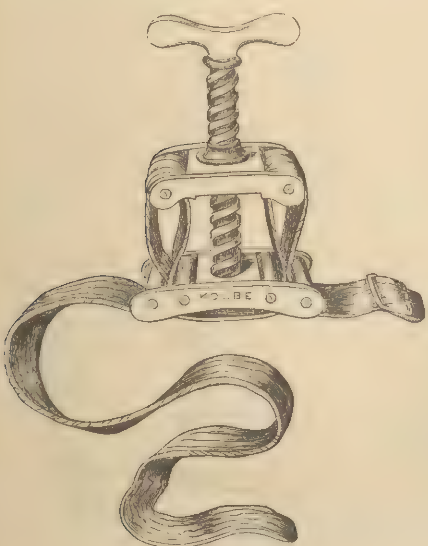
The garrot, or Spanish windlass, is well adapted to arrest bleeding in cases of emergency and where no tourniquet is at hand. A handkerchief folded into a cravat, and knotted in the middle for a compress, should be tied loosely about the limb and twisted with a walking-cane or stick (Fig. 83); or, if the knot is insufficient to compress the artery, a small stone, in the absence of a better compress, may be enveloped within it.

Fig. 83.

Application of the Spanish windlass.

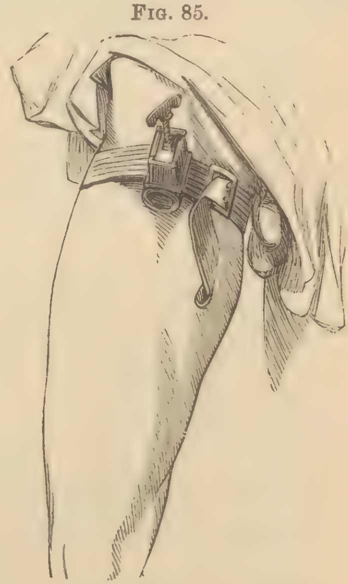
The most effectual device for the temporary arrest of hemorrhage is the tourniquet. There are several forms of this instrument. Leaving out the old contrivance of the plate and screw of Scultetus and the more improved one of Morel, we are indebted to Petit for the tourniquet so generally in use. (Fig. 84.) To apply it properly the limb should be surrounded with a few turns of a roller to protect the skin from pressure, while the body of the bandage is laid over the artery to act the part of a compress. (Fig. 85.) The base of the instrument should be placed over the compress, and the strap buckled on the outside of the limb, the opposite to that represented in the cut, after which, by turning the screw at the top, the pressure can be regulated at pleasure. If kept too long upon the limb its presence becomes exceedingly painful, and may produce mortification. I have seen a patient almost lose his life by loosening the instrument, preferring to die from the loss of blood rather than endure the torture. In the selection of a tourniquet, care should be taken that the strap is made out of linen webbing and that the buckle is a strong one, so that when once applied it can be trusted.

Fig. 84.



Tourniquet of Petit.

Fig. 85.

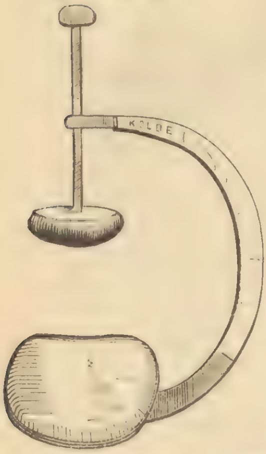


Tourniquet applied to the thigh.

As it is the constriction of the limb which produces the severe suffering

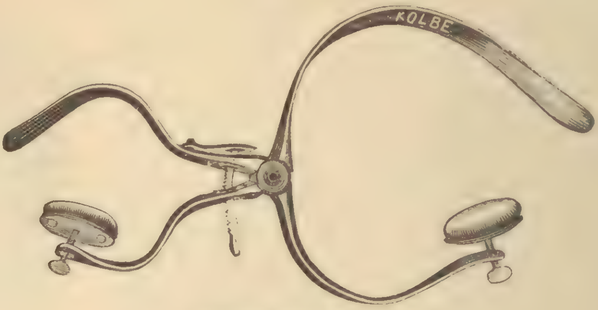
attendant on the protracted use of the tourniquet of Petit, others have been invented, which, acting only on opposite portions of the limb, do not interfere with the venous circulation, and which, though not so safe or secure as the

Fig. 86.



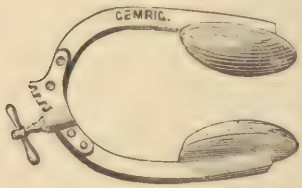
Lister's tourniquet, which, when applied, affects only the circulation through the main artery.

Fig. 87.



Professor Gross's tourniquet.

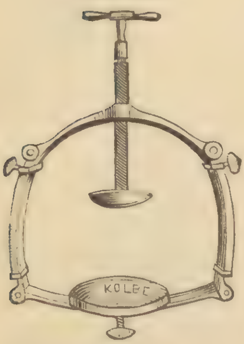
Fig. 88.



Signorini tourniquet.

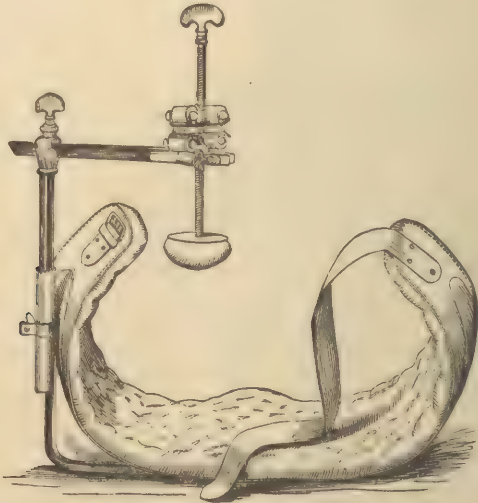
one described, yet, where it is necessary to keep an instrument for many hours on the limb, may be used with great comfort to the patient. Such is the tourniquet of Lister. (Fig. 86.) The horseshoe tourniquet of Professor Gross (Fig. 87) and that of Signorini (Fig. 88) act much in the same way.

Fig. 89.



Skey's abdominal tourniquet.

Fig. 90.



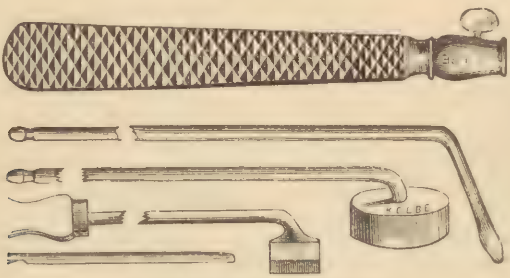
Abdominal tourniquet.

Where it is desired to command the circulation of the lower extremities by compressing the abdominal aorta, we have a valuable instrument in the tourniquet of Mr. Skey. (Fig. 89.) It is constructed so as to encircle the

body, with a posterior pad resting against the lumbar spine, and an anterior one, which can be run down by a screw, forcing the abdominal parietes upon the abdominal artery, a little to the left of the umbilicus. A modification of this tourniquet is shown in Fig. 90, though it will be found, I think, less secure, in consequence of its liability to slip out of place.

Cauterization.—The use of the hot iron is one of the most ancient means of arresting hemorrhage. Its action is mechanical, by forming out of the charred tissues a compress or obstruction at the end of the vessel. It is by no means an obsolete resource, and is frequently employed to seal up the flow of blood from a deep-seated vessel or vessels out of the reach of the ligature, or where there is a free oozing of blood from numerous points, such as occasionally follows extensive operations on the maxillary bones, in the removal of hemorrhoids, and sometimes after excision of the tonsils. There are various forms of cauterizing-irons (Fig. 91), as the olive, the button, the axe, and

FIG. 91.



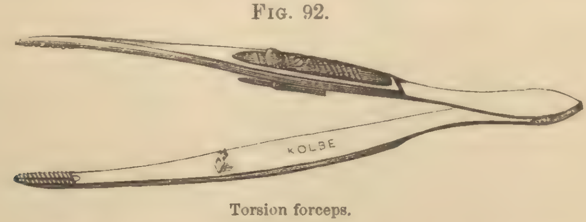
Several forms of cauterizing-irons.

others, modified to suit different localities. We may extemporize a cautery by using a piece of iron wire, a knitting-needle, or a stove-poker. That the cautery may exercise the proper effect, care must be observed to raise it to the proper temperature,—a dull red heat. If carried above this point, to an intense red or white heat, it will not only destroy the end of the vessel, but will also at the same time remove the charred portion as the cautery is withdrawn, leaving the orifice of the artery open. The slough made by the actual cautery usually comes away in the course of seven or eight days; and the wound should be carefully watched about that time, to provide against secondary bleeding, which may follow the separation.

Galvano-cautery.—Another method of applying the cautery is by the electro-galvanic battery,—an expensive apparatus, and not likely to be in the hands of professional men generally. Its use will be described in another—the operative—division of this work.

The methods thus far described must be considered, except in cases of small vessels, as only temporary, to meet present urgencies. We now pass to the consideration of methods which are designed to be permanent. These are *torsion*, *acupressure*, and the *ligature*.

FIG. 92.



Torsion forceps.

Torsion.—To apply torsion to a vessel a pair of stout forceps are required, with serrations not sufficiently sharp to lacerate the artery. (Fig. 92.) The

vessel, being seized, should be drawn well out into view and the forceps rotated until all resistance ceases (Fig. 93), but not to the extent of breaking off the end. This is the plan as practiced by Thierry, Velpeau, Fricke, and Bryant. In small vessels the last precaution need not be observed. Should the artery be diseased, the rotations should be fewer in number.

Fig. 93.

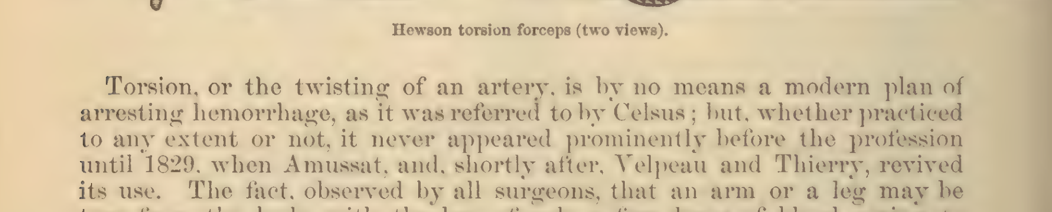
Torsion of an artery.

Fig. 94.

Amussat's plan of applying torsion.

The effect on the vessel is not unlike that produced by ligature: the internal and middle tunics break and become curled in, while the external or connective-tissue coat is formed into a tight twist below. Another plan—that of Amussat—consists in drawing out the vessel with one pair of forceps and seizing it at a right angle to its longitudinal axis with another pair, the blades of which should be pressed sufficiently firmly to lacerate the internal tunics, while the twist is made with the first pair of forceps. (Fig. 94.) A very ingenious forceps for the torsion of vessels has been devised by Dr. Addinell Hewson (Fig. 95), which combines in one instrument the two used by Amussat and others.

Fig. 95.



Hewson torsion forceps (two views).

Torsion, or the twisting of an artery, is by no means a modern plan of arresting hemorrhage, as it was referred to by Celsus; but, whether practiced to any extent or not, it never appeared prominently before the profession until 1829, when Amussat, and, shortly after, Velpeau and Thierry, revived its use. The fact, observed by all surgeons, that an arm or a leg may be torn from the body with the loss of only a few drops of blood, owing to the twisted and lacerated condition of the vessels, no doubt suggested this method. Like a prudent and conscientious man, unwilling to jeopardize human life on a theory or speculation, Amussat commenced his experiments on the lower animals, and, having succeeded, even in vessels as large as the

femoral and carotid, he adopted it in operations on the human subject, in one case applying the method to the axillary after an amputation at the shoulder-joint. The same year, M. Leiber, Rust, and Dieffenbach, of Berlin, Fricke, of Hamburg, Schroeder, of Dresden,* and, shortly after, Koch, of Munich, practiced it, with, as they affirm, entire success. The French surgeons appear not to have been so successful, Delpech and Louis having failed in several instances. The subject, however, was deemed of sufficient importance by the Institute of France to demand a careful examination, and accordingly Baron Dupuytren was appointed to make a report on the subject: this report was unfavorable to the method except as applied to small vessels.† After passing out of use, it was again revived by the late Professor Syme, and has been for three years applied by Mr. Bryant, and also by Foster, of Guy's Hospital, London, to all vessels of the extremities and superficial parts of the trunk, without accident. In America, torsion has not been received with much favor. Dr. Hewson has used it at the Pennsylvania Hospital, and speaks favorably of his success.

The advantages claimed for it are—1. The facility with which it can be practiced. In answer to this I may say that I have seen as much time consumed in twisting an articular artery of the arm before the bleeding could be stayed (and that, too, by one entirely familiar with the work) as would have sufficed for an amputation and all the subsequent dressings by the old method; and, further, that I have seen it fail altogether in more than one instance, compelling a resort to the ligature before the rebellious trunk could be subdued. The use of anæsthetics has in a great degree removed the necessity for excessive haste in surgical procedures. 2. Greater safety is claimed for torsion. I am not aware that we are in possession of any extended comparisons between this and other methods, but my own observations furnish instances in which secondary hemorrhage has followed torsion even of sound vessels,—a circumstance which I think rarely occurs after ligature. 3. It is said that by torsion healing is facilitated, because of the wound's being free from any irritating or foreign body. Yet the end of the twisted artery, comminuted and bruised, frequently separates as a slough, and becomes as much a foreign body as the ligature. The experience of both Velpeau and Manec goes to show that not only is this so, but also that the healing after torsion is as slow as when the ligature is used: according to the latter authority, indeed, it is even more tedious.

That large arteries, such as the femoral or the brachial, have been safely treated in this way is no doubt true: both Foster and Lee affirm that it is peculiarly suited to such vessels. That secondary hemorrhage has followed this method, and life been sacrificed, is, however, equally true; and, not being prepared to admit that torsion possesses any superiority over the ligature, I am unwilling, except in small vessels or in a hospital where patients are always under medical surveillance, to sanction its use as suited to general practice.

Arterio-version.—Dr. Weber, of the Medical Department of the University of Wooster, Ohio, proposes to turn vessels inside-out by means of an instrument which he calls the arterio-verter.‡ The execution of the task is represented as not difficult; but its success is not yet assured.

Acupressure.—The late Sir James Simpson, of Edinburgh, introduced acu-

FIG. 96.

Acupressure-pin.

pressure as a new method for arresting hemorrhage, in December, 1859. The instruments required to secure vessels by this plan are very few and

* Cooper's Surgical Dictionary, vol. i. page 861.
† Dupuytren's Clinical Surgery, vol. i. page 410.
‡ New York Medical Record, No. 234, May 1, 1875.

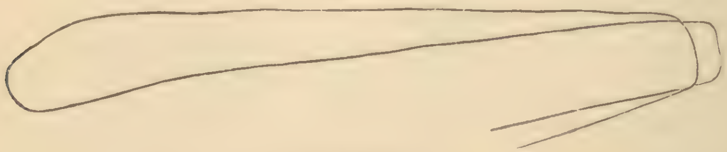
simple,—a long pin or needle with a wax head (Fig. 96), short needles with a thread of iron wire made fast to the eye (Fig. 97), and, lastly, some soft

Fig. 97.

Wire fastened to the eye of the needle.

iron wire to be used as loops. (Fig. 98.) The application of these simple instruments is made after three methods.

Fig. 98.

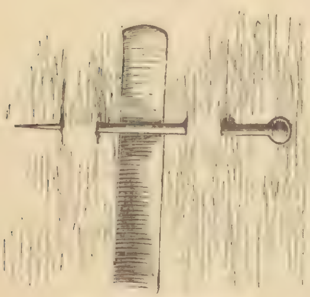


Loop of iron wire.

First method.—This consists in passing a long needle, like that represented in Fig. 99, through both sides of a wound, so as to press upon the bleeding vessel and close its canal, after the manner in which—to use Professor Simpson's own illustration—one would secure the stem of a rose to the lapel of his coat. The point of the finger of one hand being placed against the cut end of the vessel, with the other the needle is made to enter the flap on one side, and appear within two lines of the surface of the wound a very little short of the same side of the artery; the head of the pin being next depressed, the point is passed over the vessel, after which it should be raised and pushed onward until it appears at the other side of the flap or wound. (Fig. 99.)

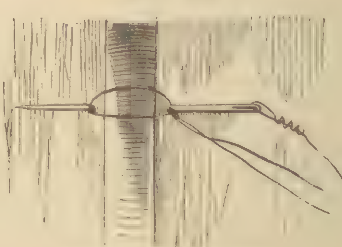
Second method.—A needle armed with an iron-wire thread (Fig. 100) is

Fig. 99.



First method of Simpson.

Fig. 100.



Second method of Simpson.

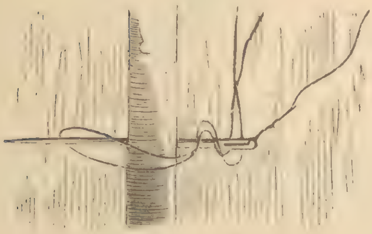
entered two or three lines on one side of a vessel, passed beneath instead of over its trunk as in the first method, and made to appear at a corresponding distance on the opposite side. A loop of wire is next slipped beneath its point, carried in front of the vessel, and made fast by twisting the ends about the other end of the needle. (Fig. 100.)

Third method.—The needle, threaded with the iron wire, is passed beneath the vessel. The loop of wire thread is placed under the point of the needle and in front of the vessel, as in the second method; but in securing this loop consists the difference. Instead of the ends being passed beneath the eye end of the needle and crossed to make them fast, both ends are placed together,

as a common thread or wire, and wound once around the shaft. (Fig. 101.) In both methods the wire should be made sufficiently tight to bring together the sides of the vessel.

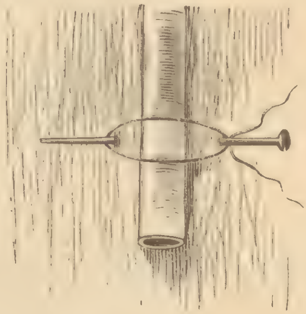
Very soon after the introduction of Simpson's method, Knowles, a house-surgeon in the Aberdeen Royal Infirmary, suggested a modification which dispensed with the loop. Other improvements were made by Professor Pirrie, of the Aberdeen University, and also by Dr. Keith. These gentlemen published an interesting paper on the subject of acupressure, in which seven methods are described.

Fig. 101.



Third method of Simpson.

Fig. 102.



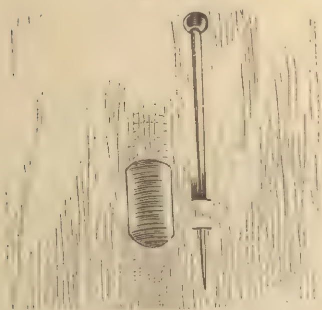
Circumclusion of an artery.

The whole subject has been greatly simplified by Professor Pirrie, in the adoption of a comprehensive classification by which the methods are all included under the three following divisions, which clearly indicate just the manner in which the vessel is treated. These divisions are styled *circumclusion*, *torsoclusion*, and *retroclusion*.

In *circumclusion* the pin is passed beneath the vessel, the wire loop placed over its point, and the ends brought over the artery and made fast, as in the second and third methods of Simpson. (Fig. 102.)

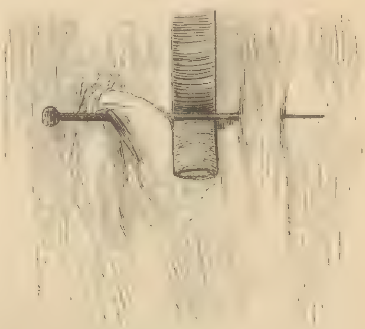
In *torsoclusion* the point of the needle or pin is pushed through a portion of tissue parallel with the course of the vessel to be secured, then carried over its anterior surface, and at the same time swept round until brought to a right angle with the artery, when the point is thrust into the soft parts beyond. (Figs. 103, 104.)

Fig. 103.



First stage of torsoclusion.

Fig. 104.



Second stage of torsoclusion.

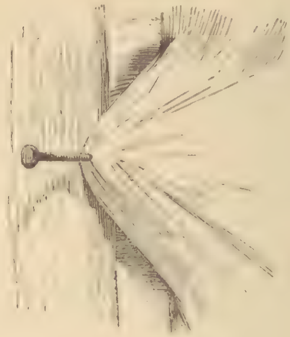
In *retroclusion* the pin is passed in and out of the tissues a short distance from the side of and at a right angle with the vessel, then passed in front of the artery to the opposite side, after which the pin is reversed, the head being carried over, and the point, returning to the side of entrance, is pushed into

the soft parts beneath the vessel. (Figs. 105, 106.) To these methods may be added that of Dr. Buck, of New York, which is a combination of torsion and

FIG. 105.

First stage of retroclusion.

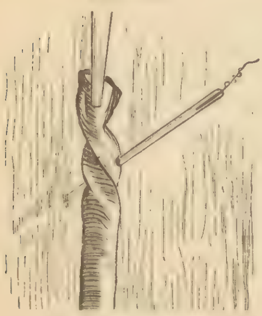
FIG. 106.



Second stage of retroclusion.

transfixion. In applying it the artery is first seized with a pair of torsion forceps and twisted two or three times on its axis, when the pin is thrust through the vessel close to the instrument, and fixed in the surrounding tissues. (Fig. 107.)

FIG. 107.

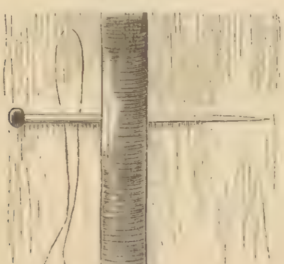


Dr. Buck's method.

Dr. Hutchison, surgeon to the Brooklyn City Hospital, describes another method applicable to vessels in their continuity. It consists in first exposing the vessel by a preliminary incision, and placing along its side a loop of wire, then entering a pin from the cutaneous surface, carrying it through all the structures and onward over the wire, beneath the vessel, bringing out the point on the opposite side. The loop of wire is then carried in front of the artery and over the point of the pin, after which the ends are next drawn upon and fastened about the exposed portion of the pin. (Figs. 108, 109.) This is a form of circumclusion like the third method of Simpson, though less practicable.

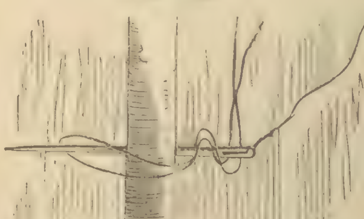
Professor Nathan R. Smith, of Baltimore, has suggested an instrument which embodies also the idea of circumclusion. It is a loop of wire passed

FIG. 108.



First stage of Hutchison's method of circumclusion.

FIG. 109.



Second stage of Hutchison's method of circumclusion.

through a double silver canula, by which the end of the divided artery is lassoed and the canula brought out of the wound. The disengagement of the apparatus is effected by pulling one end of the wire, by which it is made to cut through the vessel. It is not probable that such a contrivance will meet with very general favor.

An instrument invented by Dr. Spier,* surgeon to the Brooklyn City Hospital, has been highly spoken of by Professor Hamilton. It consists of a flattened metal tube, through which runs a rod having a hook at the end sufficiently blunt not to cut an artery, and which can be protruded or retracted by means of a screw. (Fig. 110.) In using the instrument the hook is pushed out and placed round the artery, the screw at the opposite end is then turned, and as the hook recedes within the tube the inner and middle coats are crushed and will retract; after which it may be disengaged, when it will be found that the bleeding is entirely arrested. It has been used with entire success on vessels of the size of the femoral, and acts very much after the manner of torsion.

FIG. 110.

Dr. Spier's artery-compressor.

Different kinds of forceps have been in use at various times to control bleeding from vessels too deeply placed to be reached by the ligature, such as those of Professor Gross (Fig. 111) and Nunneley of Leeds, and still more

FIG. 111.

Gross's forceps for deep vessels.

recently those of Verneuil, who has coined a word for the plan, namely, *forci-pressure*. Desault advocated such contrivances as far back as 1790. Instruments of this kind are often valuable to the surgeon when it is desirable to complete an operation before permanently securing the vessels. Such are the serres-fines (Fig. 112) and the small spring forceps (Fig. 113).

FIG. 112.

Serres-fines.

FIG. 113.

Spring forceps.

Dr. Pollock, of Pittsburg, adopted a plan of controlling hemorrhage by passing a loop of pliable wire about a bleeding vessel after amputation, bringing the ends out through the integument, a little distance apart, and securing them over a roll of muslin or other material. The same method was employed by Dix,† of England, and was, indeed, practiced as early as 1543 by Marianus Sanctus, and in 1553 by Alphonsius Ferrius,‡ two Neapolitan surgeons; also by Ambrose Paré and Jacques Guillemeau, in 1594: all, however, used silk thread in place of wire.

Ligature.—The direct or immediate application of a thread to a wounded

* Transactions of the International Medical Congress, Philadelphia, 1876, Proceedings of Surgical Section.

† Edinburgh Medical Journal, Sept. 1864, page 213. ‡ Simpson on Acupressure, page 312.

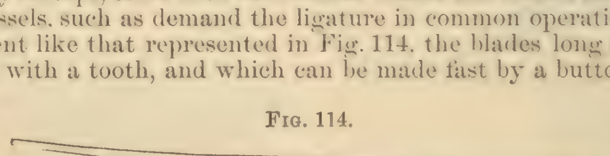
vessel is, on the whole, the most satisfactory mode of arresting hemorrhage. There is a feeling of security which attaches to no other plan, and which enables the surgeon to leave his patient at whatever distance, feeling, if the artery be sound, that he is absolutely safe. It is impossible to fix the period when the ligature was first used for the arrest of hemorrhage, or the surgeon who was the first to apply it. It was well known to Celsus in the first century of the Christian era, and still later it was used by Galen, Avicenna, Guy de Chauliac, and others; but the glory of introducing it as a hæmostatic in amputation is unquestionably due to Ambrose Paré, who in 1564 published his new discovery, the knowledge of which, to use his own language, he was taught by the special favor of the sacred Deity. When it is remembered that before this bleeding was generally stanched by hot irons, humanity can never be sufficiently grateful that God put it into his head and heart to work such a deliverance. On account, however, of the opposition of Gourmelen and the criminal neglect of surgeons generally, it was two hundred years before this discovery of Paré was adopted by the profession, and then it came into favor chiefly through the influence of Sharpe, one of the surgeons of Guy's Hospital, London, who boldly championed the claims of the ligature to popular confidence.

The materials employed for constructing ligatures are silk, hemp, flax, silver, lead, iron, and different animal substances. Uncolored silk is preferred by most surgeons. Before adopting the animal thread I had been in the habit, for a long time, of using either flax or hempen material, and was rarely annoyed by finding it break in the hands of an assistant while tightening the knot. For those who are partial to the use of silk as a ligature there are two kinds which answer best, viz., the saddlers' and the dentists'.

Ligatures, of whatever material, should be round, as their pressure is then more uniform and concentrated than when flat or ribbon-shaped. For small vessels, like those divided in removing a scirrhous mamma or a fatty tumor, the thread need not be larger than ordinary sewing-silk and should be about nine inches in length; and indeed this size is quite large enough for arteries such as the radial, ulnar, or tibial. For vessels like the femoral, iliac, or axillary, a single strand of saddlers' silk is sufficiently stout. Two sizes will answer all cases. The great cords sometimes employed, resembling fishing-lines, are entirely unnecessary. The thread should always be well waxed, in order to prevent the loosening of the first knot and to render the ligature less irritating from the coating of an animal substance.

When the silk or hemp cord is used, the vessel should be drawn out, either by an artery forceps or by a tenaculum. There are several varieties of the artery forceps, some with rat-toothed blades and others serrated. For ordinary vessels, such as demand the ligature in common operations, I prefer an instrument like that represented in Fig. 114, the blades long and slender, each armed with a tooth, and which can be made fast by a button slide.

FIG. 114.



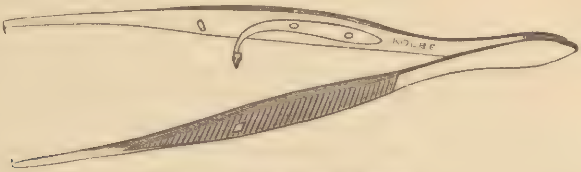
The author's artery forceps.

Another forceps, somewhat like this, but with shorter blades and having a curved spring catch (Fig. 115), is preferred by some. This spring or fastening is liable to get out of order, and consequently detracts from the value of the instrument.

Many prefer forceps having fenestrated blades, of which there are several patterns. The one delineated in Fig. 116 has a slide catch, which serves to fasten the blades together. In Fig. 117 is represented a form of forceps which

open by pressure and close by the spring of the blades. With this instrument the surgeon can secure a vessel without an assistant, as it will retain its hold and by its weight draw the vessel out while the thread is applied. There is

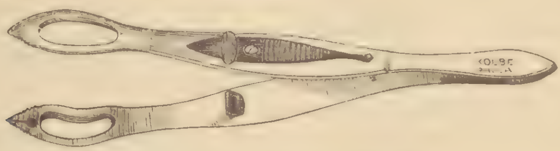
FIG. 115.



Sometimes called Liston's forceps.

another fenestrated instrument (Fig. 118), the blades of which, from their convexity when closed, greatly facilitate the passage of a ligature over the vessel.

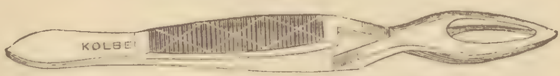
FIG. 116.



Fenestrated forceps, with a slide catch.

Whatever form of artery forceps is used, it is desirable to have such as possess a mechanism that will hold the blades together when once closed.

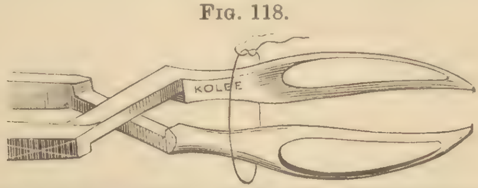
FIG. 117.



Artery forceps which close by the spring of the blades.

The tenaculum invented by Bromfield, surgeon to Guy's Hospital (Fig. 119), is perhaps more generally used among American surgeons than the forceps. The curve should be neither too abrupt nor too straight.

FIG. 118.



Fenestrated spring forceps, with a ligature ready to be slipped down and tied.

In applying the ligature the vessel should be seized either by the tenaculum or by the forceps and drawn out from the parts in which it is buried. It

FIG. 119.

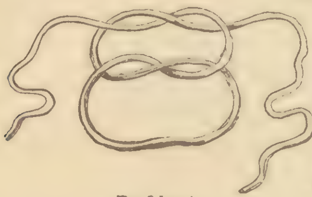
Tenaculum for taking up vessels.

should, as far as possible, be carefully isolated from every other structure. Veins and nerves are generally closely associated with the arteries, and neither of these should be included within the compass of a ligature. The ligation of a nerve will produce severe suffering, and often spasm of the limbs.

From this cause I have known a patient to die of tetanus, and others to suffer greatly until the thread was detached. When Lord Nelson's arm was amputated in consequence of a gunshot injury of the elbow-joint, his surgeon included a nerve along with the artery. The ligature did not separate for four months, during the whole of which time his sufferings were very great.* Some of the older surgeons, as stated by Petit, considered the tying of a nerve along with a vessel to be of little consequence, and no less eminent a surgeon than John Hunter† entertained the same notion. Even in the securing of small vessels it is desirable to embrace nothing but the artery, although this is rarely done, as it is hardly feasible not to include some of the surrounding tissues: the rule, therefore, should be to embrace just as little as possible. In diseased vessels, such as are calcified, and where the coats are very brittle, it has been advised to tie a cushion of the soft parts about the artery, so that the ligature shall not separate too soon, and thus to give time for the occlusion of the vascular canal. I have often adopted the plan, and with gratifying success. With the same object in view, some direct the use of a flat ligature, as being less likely to cut rapidly through the vessel than if round. Cline, the elder, used this, with an interposed piece of cork. Scarpa substituted for the cork a piece of linen; and Manec advised the introduction of a piece of bougie into the canal of the vessel before the application of the thread. The advantages of all such contrivances are exceedingly doubtful. Indeed, I cannot recall a case of secondary hemorrhage in such a condition of the arteries, where the usual ligature was employed, and think the danger is over-estimated.

The ligature having been placed about the artery, it should be made fast by the ordinary surgeon's or by the reef knot (Fig. 120), in tightening which either

Fig. 120.



Reef knot.

Surgeon's knot.

the index fingers or the thumbs should be run down near to the vessel (Fig. 121), taking care that the thread is above the point of the forceps or beneath the point of the tenaculum, according as one or the other instrument is employed, and that no more force is used than is necessary to secure it firmly upon the vessel. Few persons apply a ligature quickly and at the same time gracefully. It requires no great exertion of muscular power, and, were it not for the annoyance arising from delay consequent on broken threads, it would be amusing to witness the awkward display of physical strength which many surgeons exhibit in performing the simple act of bringing together the walls of an unresisting artery.

Fig. 121.

Position of the fingers in tightening a ligature.

When the ligature is tied, one end should be clipped off quite close to the knot and the other brought out of the wound (Fig. 122), for which improvement we are indebted to James

* Simpson, Acupressure, page 29.
† Works of John Hunter, vol. i. page 541.

Veitch, Esq., at one time surgeon to the Naval Hospital at Plymouth. Some surgeons have recommended cutting off both ends close to the knot and closing the parts. It is difficult to determine by whom this plan was first practiced. It would appear that as far back as 1786 it was in use by Mr. Lancelot Haise, assistant surgeon to the Haslar Hospital, and in 1798 the method was adopted by Dr. Maxwell, of Dumfries.* It was frequently done at St. Bartholomew's by Mr. Laurence as early as 1814. It was suggested to Hennen in 1813 by assistant staff-surgeon Hume, who stated that it was the practice of an American naval surgeon. Hennen, favorably impressed with the plan, treated a number of cases in this way, both at the time and subsequently at Waterloo, and with such success as to justify a favorable report to Dr. Charles Forbes, deputy-inspector of hospitals. In 1814 it was practiced by M. Delpech. A more extended experience, however, has shown that, while in some cases these little knots become encysted and remain harmless in the tissues, in a large number of instances they act as irritants, retard healing, provoke abscesses, and are subsequently discharged from the wound: so that the plan may be regarded as an unsurgical procedure.

The time required for the disengagement of a silk or hempen ligature from a vessel will vary from three days to three weeks, according to the size of the vessels. They appear to separate more slowly when applied in the continuity of a vessel, and it is not uncommon to find a ligature on an artery like the femoral or iliac quite firm after the lapse of twenty or twenty-five days. Much also depends on the amount and nature of included structures. When dense fibrous or ligamentous tissues are embraced with the vessel, the separation will be tardy, from the slowness of ulceration. I have seen a ligature adhere to the radial for twelve weeks from this cause.

Ligatures should be brought out of the angles of a wound, when not too distant; or, if too remote, at the nearest point to their attachment. To prevent their being prematurely disturbed in the removal of dressings, they should be collected together and secured to the skin by strips of adhesive plaster. Those commanding large vessels should be distinguished from the others by making a knot at the end. The removal of ligatures is effected by making gentle traction on the ends projecting from the wound. This, after five or six days, will be sufficient for the separation of those attached to the ordinary muscular branches, but will be too soon by several days for such as secure the principal trunks of a part. At each successive dressing those which remain should be subjected to the same manipulation. When a ligature is retained several days longer than is usual in similar cases, we can frequently remove it by simply twisting it several times between the thumb and the index finger; and should this fail, a most effectual plan will be found in taking a light gum ring, such as is often used to hold together packages of letters, and, fastening the ligature to one end of the elastic loop, fix the other, slightly on the stretch, to the skin. (Fig. 122.) The constant and uniform traction of the gum will soon accomplish detachment of the thread.

FIG. 122.

Elastic loop attached to a retained ligature.

Animal Ligatures.—The use of animal ligatures was first suggested by Dr. Physick in 1814, under the impression that such a material would consort kindly with the tissues, and undergo softening and absorption. The late Dr. Jameson, of Baltimore, used buckskin cut into narrow strips and firmly rolled. A short time before his death the doctor informed me that he had tied with this material all the accessible arteries of the body. Dr. McSweeny, of Cork, recommended the gut of the silk-worm, and Sir Astley Cooper at one time used catgut. He tied the femoral artery successfully with this material in a case of popliteal aneurism. This same substance is used by Mr. Lister, being treated first by carbolated oil and rendered antiseptic. It should be kept in a bottle immersed in the acid and oil, and only taken out when required

* Hennen, Military Surgery, p. 178.

for use. The longer the catgut is kept in the mixture the more flexible and reliable it becomes.* There can be little doubt that catgut treated in this way is superior to all other forms of ligature. It produces the least possible irritation or suppuration, and closes the vessel often without the division of its coats, as appears from a case of Holmes,† in which the subclavian and carotid were ligatured. The death of the patient two months after from another cause afforded an opportunity to examine these vessels, when both were found closed by a thin septum without any separation of the external coat. An additional advantage is the facility with which the ligature is absorbed, enabling us to secure the quick healing of wounds. These conditions, together with an encapsulating ring of lymph which is not disturbed by suppuration, contribute immensely to the safety of the patient, especially one with diseased arteries, against the occurrence of secondary hemorrhage. The few cases recorded in which the catgut softened and became partially untied do not in the least affect my confidence in this ligature: it is the only one which I employ, and after its use I have never seen abscess or hemorrhage. The only precautions to be observed are, not to use the thread until it has been macerated two or three months in the carbolic acid and oil, to draw it between the thumb and finger in order to remove the adherent oil, to adjust the knot with care, and to leave the ends about one-quarter of an inch in length.

At one time I used for ligatures the fine plaster made from the peritoneum of the bullock, cutting it into narrow strips and rolling them into round threads. These cords maintained their hold on the vessels satisfactorily, but did not possess sufficient strength for large arteries.

Dr. Paul Eve speaks favorably of threads stripped from the sinews of the deer. I have used threads prepared from the sinews of the giraffe, which are very strong and pliable, but possess no advantage over catgut.

Metallic Ligatures.—The growing popularity of silver and lead wire as a surgical suture has directed the attention of the profession to their use for the ligature of arteries. Though we are not in possession of a sufficient number of cases to warrant any general deduction, yet on the whole the results are not unsatisfactory. Wire provokes very little irritation, and is soon encased in a wall of lymph, becoming permanently encysted. The lead ligature, had it sufficient strength, would be unquestionably the least irritating of non-absorbable threads. In 1859, Dr. Stone, of New Orleans, tied the common iliac with a silver thread, since which time this wire has been applied by Professor Gross to the femoral, by myself to the brachial, and, in 1866, by Dr. Charles H. Mastin, of Mobile, to the external iliac. In the use of the metallic as in that of the animal thread, both ends are cut off, but the final disposition is quite different in the two cases. In the latter, as already stated, the ligature is expected to become soft, disintegrate, and disappear entirely by absorption, and in the first, to become encapsulated by the inflammatory deposition of lymph.

Comparison of Hæmostatics.—What is the great desideratum in a mechanical hæmostatic? The answer to this question is obvious, viz., that which in addition to safely closing the vessels interferes least with intermediate union or the so-called union by the first intention.

The objections urged against the thread ligature may all be embraced under the following heads: It is incompatible with the nature of the tissues in which it lies; it is a foreign body, and acts the part of a seton; and its separation involves inflammatory consequences, which increase the amount

* The time required to prepare catgut for use as a ligature has been reduced by Mr. Lister to a few days, instead of months, as formerly: this is effected by adding to the carbolic acid and sweet oil a small amount of chromic acid, which renders the catgut strong and pliable and deprives it of all tendency to become untied when placed around an artery. See Transactions of the International Medical Congress at Philadelphia, 1876, Proceedings of Surgical Section.

† Holmes's Principles and Practice of Surgery, page 120, American edition.

of foreign matter in a wound; that is to say, the formation of pus, and the disintegration and mortification of the strangulated ends of the vessels, give rise to the production of matters which not only retard healing, but by their absorption into the vessels tend to poison the blood and produce pyæmia and undue surgical fever. My answer in general to all such charges against this time-honored thread is this: "*not proven.*" There are no statistical facts, sufficiently numerous or extended, to warrant any such conclusions.

If we wait until wounds can be saved from the presence of "minute morsels of dead flesh,"—the sarcastic remark of the late Sir James Simpson against the ligature,—we shall wait in vain. This condition is inseparable from every wound; it is a mechanical necessity, resulting from the serrated edge of every knife, however sharp, and explains the minute specks or points which are seen studding an incised surface, and which are indeed miniature sloughs, the result of the injury. Leaving this out of the question, what methods do not induce, in some degree, the same results? Torsion of a vessel destroys the vitality of the walls to a greater extent than does the ligature; and secondary hemorrhage is at least as frequent after the employment of the former method as it is after the use of the latter. In a series of twenty amputations, I am very certain that the healing will be as rapid where the vessels have been treated by the ligature as where they have been subjected to torsion.

If a comparison be made between the relative merits of acupressure and the ligature, the advantages of the latter appear to me to be quite evident. It is by no means established that the subsequent healing differs in any particular, or that the wound unites more quickly by one than by the other plan. There are, however, certain objections which, in my judgment, may be urged against acupressure: 1, there is greater liberty taken with the vessel, that is, a larger extent of the vessel is disturbed than by the ligature, especially in executing the methods of torsoclusion and retroclusion; 2, it includes a much greater amount of the surrounding soft tissues; 3, by pushing needles blindly through the flaps of a stump or into the tissues, out of sight, in order to maintain the resistance necessary to form adequate pressure, one can scarcely avoid wounding contiguous nerves; 4, it gives no superior safety against secondary bleeding; 5, it places too much power in the hands of the patient, who may from curiosity or thoughtlessness easily pull the needle or pin from the vessel; 6, there are no accumulated observations which establish, as a consequence of the method, a less degree of liability to surgical fever, pyæmia, or any other accidents incident to wounds.

The objection charged against the ligature of being a seton I do not accept as valid: indeed, if the evil effects stated to arise from its use by producing sloughs and infective fluids from their decomposition are really produced, then the presence of a seton becomes a most important safeguard by conducting all such débris out of the wound. No one conversant with surgical dressings can have failed to notice the moist condition of ligatures due to this very office which they perform. When we attempt a comparison between the animal and the common ligature, there are several considerations which give to the former, especially to the antiseptic catgut ligature, the strongest claims to professional support. That it lies harmless and unirritating in contact with the tissues, with little, if any, tendency to provoke suppuration, and is finally removed by absorption, are facts which cannot be gainsaid. The tendency of these ligatures to soften too quickly, and of the knots to become untied, thus relaxing their hold upon arteries, was formerly an objection to their use in the case of large vessels; but this objection is no longer valid, as the material can be now treated so as to render the knot entirely fixed and at the same time impart greater flexibility and strength to the thread.

Time only can determine the true value of the metallic ligature when applied to large arteries in their continuity, like the iliac, femoral, and brachial: it is certainly badly adapted to purposes of general ligation.

General Treatment of Hemorrhage.—When a large loss of blood has been sustained, followed, as it usually is, by a state of syncope, and the surgeon is not prepared for operative measures, he should not be too forward in establishing reaction, although it is his duty to guard against the risks of cerebral anæmia by keeping the patient in the recumbent position, with the head on a plane with, or even lower than, the rest of the body. Syncope, as has been already stated, favors the arrest of bleeding, and therefore offers a truce, during which time the surgeon provides against any recurrence. When hemorrhage has been so excessive or prolonged as to endanger life, everything depends on sustaining the great nerve-centres from which emanates the motor power of the heart. The body should be placed on an inclined plane, the head being dependent, and the extremities tightly bandaged from the feet and hands to the trunk, so as to secure as much blood as possible in the brain; there should be a free access of cool air to the apartment, although the body must be kept warm by the application of dry heat; volatile stimulants, like ammonia, are to be held to the nose, in order to excite the respiratory movements, and brandy cautiously given in milk, both as a stimulant and to replenish the empty blood-vessels. When the bleeding is from small vessels, like those of the nose, lungs, or uterus, the surgeon has the choice of several remedies, which may be administered internally, and which possess very decided hæmostatic properties. These are the fluid extract of ergot, twenty drops every half-hour; turpentine, ten drops in a mucilage every half-hour, watching its effect on the bladder; gallic acid, ten grains every twenty-five minutes; acetate of lead, three grains every two hours; oil of erigeron Canadensis, five drops every ten minutes. Opium is a most valuable remedy, and should be given, in some of its forms, in doses sufficient to control all restlessness and mental anxiety. To replenish the vessels as rapidly as possible, milk should be given freely, and occasionally some strong coffee. To remove the effects of hemorrhage,—as anæmia, palpitation, and nervous irritability,—the tincture of the chloride of iron, a generous diet, and good wine are the best remedies.

Transfusion.—When a patient is in danger of perishing from hemorrhage, resort should be had at once to transfusion,—that is, the introduction of blood from a sound person into the vessels of the patient. I have seen individuals dying from epistaxis rescued from the very verge of dissolution by the timely passage of a few ounces of blood into a vein of the arm. Not only is such a course indicated in excessive hemorrhage, but I have known several cases of obstinate anæmia greatly benefited by the same practice. It is an operation requiring skill and delicacy of manipulation. There are two methods for effecting transfusion,—*immediate* and *mediate*. By the first, the blood, without being subjected to any treatment, is transferred directly from one person to another; by the second, it is drawn from the vein of one into a vessel, and, after having been deprived of its fibrin or not, according to the preference of the operator, is thrown, by means of a proper instrument, into the vein of another. Hueter, of Greifswald, advises the blood to be thrown into the arterial in preference to the venous system, believing that thus it passes to the heart in a more even and less rapid manner.

The points for consideration in transfusion are the following: 1, the cases which are suitable subjects for such an operation; 2, the proper kind of blood to be used; and, 3, the best instrumental appliances for executing the operation.

First. Cases demanding transfusion are all such as are in a state of dangerous exhaustion from loss of blood, whether from wounds, epistaxis, or post-partum hemorrhage; cases of obstinate and progressive anæmia; in fact, all instances of extreme debility, the result of blood deterioration, and where there is no organic disease, necessarily incurable, as phthisis pulmonalis and cancer.

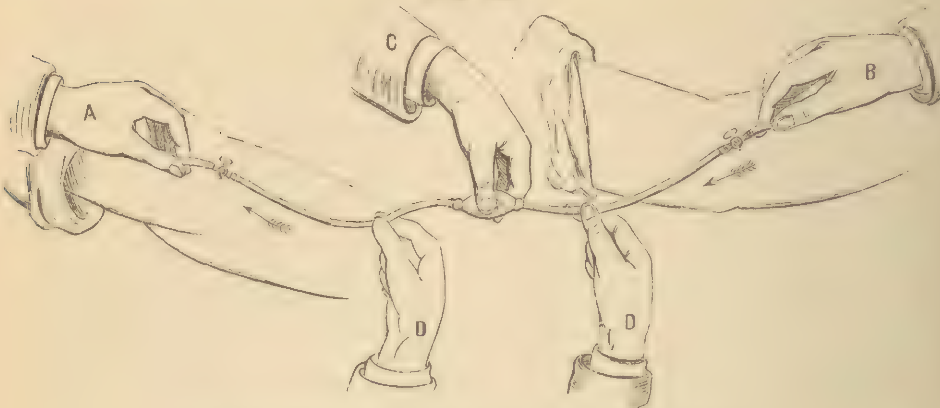
Second. The proper kind of blood to be used.—It should be human blood,—arterial or venous,—from a person of known good health and free from any

constitutional vice. The blood may be used as drawn, or it may be defibrinated; the former I think the preferable plan. One of the difficulties anticipated was the coagulation of the blood before its transference from the giver to the receiver, and, in order to prevent such a contingency, reservoirs, funnels, and glass cylinders have been invented, so as to have a surrounding chamber for warm water, in order to maintain the blood at the temperature of the body. Purman and Dennis entertained these fears of coagulation from cold, and adopted contrivances to prevent it, the former by a tube surrounded with a linen cover containing warm water, and the latter by advising that the operation be executed in a hot-water chamber. At present, however, it is ascertained that danger from this cause is imaginary, and that cold is just as likely to prevent or delay coagulation as heat. Dr. Richardson recommended at one time the addition of a few drops of ammonia to each ounce of blood, with a view to maintain its fluidity, and Braxton Hicks, still later, used a solution of phosphate of soda for the same purpose. The plan of defibrinating the blood arose from this same idea of coagulation. This is accomplished by drawing the blood into a vessel and whipping it, until deprived of its fibrin, with a piece of broom-corn taken from a new broom, freed of the seed-capsules, and thoroughly cleansed; then passing the residuum through a piece of linen or a wire strainer, as in the Hunter apparatus, thus leaving only the blood-corpuscles and serum for injection. It is quite certain that blood deprived of its fibrin is not in the least deteriorated in value for the purpose required; but, with the proper apparatus on hand for immediate or direct transfusion, I can see no necessity for subjecting the fluid to any preliminary treatment.

Third. The proper instruments or apparatus.—A great variety of contrivances have been in use at different periods for this purpose. If the immediate plan be adopted, which I certainly prefer, we have in the Aveling syringe all that can be desired. It is a simple india-rubber tube, with a bulb in the middle, without valves. At each end of the rubber tube is a stop-cock, into which is fitted a silver tube, one round and blunt-pointed, the other sharp and beveled; a scalpel, thumb lancet, and pair of forceps make up the complement of instruments. When the apparatus is to be used, the metallic tubes must be detached from the rubber part of the syringe, and the latter dropped into a basin of tepid water and filled with the liquid, first squeezing the bulb, to expel all air, and then allowing it to draw in the water, after which the stop-cocks must be closed, in order to prevent its escape. The patient should be brought to the side of the bed, and the most prominent vein at the bend of the arm laid bare by raising a duplicature of skin, transfixing and dividing it with the sharp-pointed bistoury. The vein is next grasped with the forceps, incised, and the oblique-pointed tube, previously filled with water, inserted, its point being directed upwards or towards the body, and given in charge to an assistant (A, Fig. 123), who holds it in place by seizing it between the thumb and fingers. The blood-donor should now take his seat at the bedside of the patient, with his arm nearly parallel with that of the latter, and, an oblique opening having been made into the median cephalic or basilic vein, as in venesection, the round-pointed tube, likewise filled with tepid water, must be introduced into the vessel, with the point directed downwards or towards the hand, and held *in situ* by another assistant (B). The tube should next be connected with the apparatus, the stop-cocks opened, and the transfusion begun. This should be slow, and is effected by the operator pressing together the sides of the tube next to the blood-donor with the thumb and finger of one hand, while with the other he compresses the bulb of the syringe (C), by which the blood (about two drachms) is forced into the vein of the patient. The hand (D) must be next changed over, grasping the india-rubber tube on the side of the patient, releasing the bulb from pressure, by the expansion of which the blood is drawn in from the donor, when the pressure is again applied to the tube on the side of the latter and the bulb a second time compressed. By these alternate manipulations, four

or five ounces of blood can be transferred from one to the other. Great care must be taken throughout the whole procedure that no air is allowed to enter the circulation, since otherwise the life of the patient would be jeopardized.

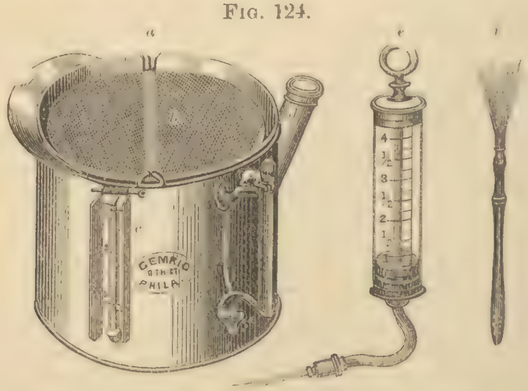
FIG. 123.



Aveling's apparatus introduced into the arms of the recipient and donor.

If the mediate plan be adopted, the apparatus of Dr. Allen, as modified by Drs. Morton* and Hunter, will answer the purpose best. This consists of a German-silver vessel, the interior of which is hopper-shaped, wide above and narrow below, provided with a very fine conical wire strainer, and having a surrounding hot-water chamber to maintain the blood at the proper temperature, to indicate which a thermometer is secured to the outside of the vessel. The syringe used to inject the blood is of glass, having a capacity of four ounces. A flexible tube is fitted to the nozzle of the syringe, and to this is attached a blunt canula, which can be disconnected at pleasure. For the purpose of defibrination, a fine wire brush is employed. (Fig. 124.)

FIG. 124.



Hunter's apparatus for transfusion: *a*, the blood-receiver; *b*, wire strainer; *c*, thermometer; *d*, tube for introducing hot water into the water-chamber; *e*, syringe, with its scale marked in half-ounces; *f*, wire brush.

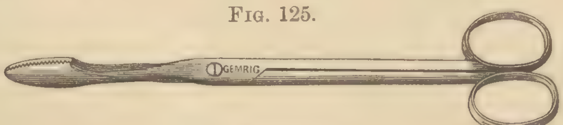
In transfusion by this instrument, or by the mediate plan, a vein is uncovered at the bend of the arm or above the inner ankle of the patient, and the canula is inserted into its canal and secured by a ligature. The most satisfactory way of doing this is to make an oblique incision over the vessel, and, carefully isolating it from its surrounding connections, lift it upon a director. An assistant should now place a finger over the vessel below, so as to inter-

* The difference between the Morton and the Hunter apparatus is in the attachment of a wire strainer in the latter.

rupt the blood-current, while the operator makes a small transverse opening in its walls, and immediately introduces the canula. This preliminary measure being completed, the next step is to open the vein of the blood-donor and allow the stream to flow into the wire strainer, where it is to be whipped with the metallic brush, in order to separate the fibrin. The corpuscles and serum pass through into the tin cup below, where they are preserved at the proper temperature by the hot water previously introduced into the water-chamber. The strainer is now removed, and the syringe, well warmed, is charged with the defibrinated blood. The piston is forced down sufficiently to expel all air and fill the tube, after which it is fitted to the pipe in the vein, and the blood slowly injected into the system of the patient, the amount necessary varying from three to ten ounces. A rigor is often experienced immediately after the transfusion, but this in a short time passes over. In some cases syncope is threatened, but the tendency to that condition quickly vanishes. If the case has been judiciously selected, and the operation dexterously executed, the improvement in the patient's condition will soon become apparent. The bloodless lips assume a better color, the pulse becomes fuller, and there is a consciousness of returning strength. The success realized by Allen, Morton,* and Hunter in transfusion entitles the subject to the serious attention of the profession.

Removal of Foreign Bodies from Wounds.—The removal of anything extraneous to a wound is the second indication. There are exceptional cases in which this becomes the first indication, as where a dagger, a pin, or pointed pieces of glass are found projecting from the divided tissues. The means of effecting this are various. When the foreign matters are sand, gravel, dirt, or clots of blood, it is best accomplished by a shower of lukewarm water pressed from a sponge held a short distance above the part, or by a stream of water from the nozzle of a syringe. Larger substances are most readily removed with the fingers, and those more deeply intrenched by the dressing forceps. (Fig. 125.) In all cases a most careful search should be

Fig. 125.



Dressing forceps.

made that no particles be overlooked, as all such complicate the process of healing. In gunshot wounds other instrumental appliances become necessary, and these will be found detailed under the head of such injuries.

There are matters of another kind which, although not usually considered in this connection, are nevertheless truly foreign and demand attention: these are certain microscopic organisms contained in the air, which it is thought are active in exciting suppuration. This doctrine, with which the name of Professor Lister, of Edinburgh, is so prominently associated, is founded on the views of Pasteur, who believed that both fermentation and putrefaction were inaugurated by such organic forms. While much may be said both for and against this germ theory, it is certainly true that in almost all cases of decomposition these low or simple organized bodies are recognized in great abundance. Whatever may be their connection with the process of decomposition, it is quite certain that when such agents are employed as prove destructive to their existence the process of healing is greatly promoted. Carbolic and salicylic acids act in this way, and weak solutions applied freely to the wound, or atomized into the air surrounding the same, offer the best means for their extinction. The mode of applying this treatment will be described hereafter (see page 187).

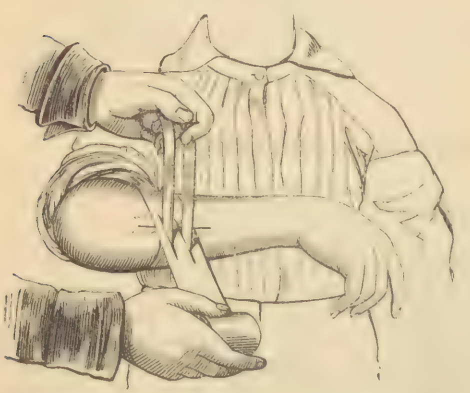
* Morton on Transfusion, American Journal of the Medical Sciences, New Series, 1874, p. 111.

The Approximation of Wounds.—The retraction or gaping of divided parts is due to the elasticity of the tissues, contraction of muscles, direction of the wound, and position. Parts that are compactly bound together, like those of the scalp or face, do not retract much, while in those in which the anatomical components are more loosely united, as the skin in front of the chest, arm, or thigh, the separation is very marked. A part closely attached to an underlying muscle—particularly when the latter is severed—will, when wounded, retract very much, and if the muscle be a cutaneous one, like the platysma myoides, the edges of the skin will be inverted. When the direction of the wound is transverse to the course of the muscles, the gaping will be much greater than when it is parallel. The separation of a wound in front of the neck, or on the back of the arm, will be greatly increased by extending the head or flexing the arm. The bringing together of the retracted edges, and so retaining them, constitutes the third indication, and is accomplished by *position*, *rollers*, *compresses*, *plasters*, and *sutures*.

Position.—By position is meant such a disposition of parts as will insure their relaxation: thus, in cut-throat wounds bringing the chin towards the breast, or in axillary wounds approximating the arm to the side, will alone effect their closure.

Rollers and Compresses.—These are employed after either an indirect or a direct manner. In the former they serve to support other dressings, in the latter they are the chief means of approximation. The preparation of a roller for the latter purpose requires that it shall be long enough to pass four or five times round the part, as, for example, the leg or arm, and in breadth equal to the length of the wound. Roll the strip into a cylinder, leaving a portion of the terminal end unrolled, which last is to be torn into two or three tails long enough to encircle three-fourths of the limb. At a proper distance, nearer the cylinder, cut a number of slits corresponding to the tails. To make the application of this so-called invaginated bandage, two compresses should be placed parallel with the course of the wound and two inches from its sides, and as the roller is brought round from the opposite side of the limb towards the wound the tails are passed through the slits (Fig. 126), and as the ends of the roller are drawn in opposite directions the edges of the wound are forced together, and so maintained by successive circular turns of the cylindrical part of the bandage. If this is used in a wound of an extremity, it should be preceded by the application of a spiral reversed bandage, carried from the fingers or toes to the seat of injury, to prevent strangulation by the invaginated roller.

Fig. 126.

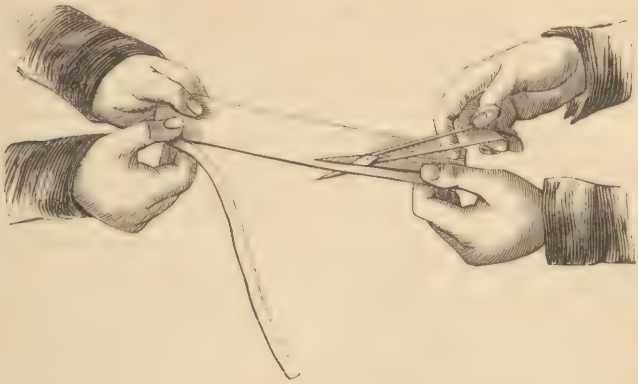


The uniting or invaginated bandage applied to a longitudinal wound of the arm.

Plasters.—Without entirely discarding others, yet after a trial with every variety I declare an unqualified preference for the ordinary *emplastrum adhæsivum*. This plaster is made by boiling together litharge and olive oil, to which is added some resin, and sometimes a little soap, the latter rendering it less liable to crack and scale off in cold weather. The mixture is spread upon muslin, is covered with tissue-paper, and made into rolls. For use it should be cut, with a pair of scissors, into strips from three-eighths of an inch to one inch in width, and from one inch to twelve inches in length, according to the extent of the wound to be closed. The plaster should be cut lengthwise of the cloth rather than transversely, to prevent stretching of the strips, an assist-

ant holding one end, while the surgeon or dresser, holding the other, uses the scissors as a knife, by pushing forward the separated blades. (Fig. 127.) The

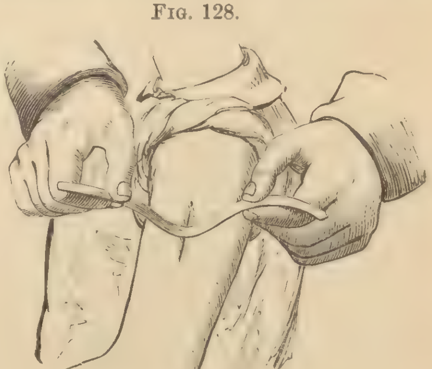
FIG. 127.



Cutting adhesive strips.

part to which the plasters are applied must be divested of all hair, and then thoroughly cleansed with soap and water, both to save the patient pain in their removal and to insure their firm adhesion. In their application, the strips should be well warmed by placing the unspread surface over a vessel. such as a bottle or tin coffee-pot, containing boiling water; or, when these are not accessible, over a stove-pipe, gas-light, or before an open fire; or, if these are not available, by rapidly passing a sponge moistened with chloroform over the plaster. When sufficiently softened, an end of the plaster should be made fast to one side of the wound, the edges of which, being brought closely together by the fingers of the surgeon, are thus retained by carrying the strip across and making it secure to the opposite side. The first strip should be applied across the middle of the wound and an interval of half an inch allowed between each, for the purpose of drainage. When applied to a wound of the extremities the plasters should not extend more than two-thirds around the part. The period for their removal will depend on circumstances. So long as they maintain their connection with the part, and the apposition of the wound is good, without any evidence of the accumulation of pus or blood, they should not be disturbed, but only cleansed by passing lightly over the surface a soft sponge moistened with tepid carbolized water. I am sure there is too much meddling with wounds, too much anxiety to renew dressings, by which the quiet and repose so necessary to the work of healing are disturbed. When the removal of plasters becomes necessary, they should be detached with great care; not by lifting one end and dragging it across the wound to the opposite side, by which the cut may again be opened, but by raising both ends at the same time and detaching last that part which lies across the approximated edges. (Fig. 128.) It is a judicious precaution, in order to avoid the risk of sundering the delicate union, to apply a fresh strip over the place of each one removed before another is raised.

FIG. 128.



Removing adhesive strip.

Great gentleness and care are necessary in cleansing a wound during the process of dressing. The discharges are best got rid of by showering,—that is, by squeezing lukewarm water, either plain or medicated by carbolic acid or permanganate of potash, from a sponge held a short distance above the parts, and pressing out any accumulations with the fingers or the sponge. If such a precaution is neglected, the union will be not only retarded but also complicated, exposing the patient to abscesses, erysipelas, or sinuses.

Ichthyocolla plaster.—This plaster is made by applying to silk a solution of isinglass in spirits of wine. The addition of a little glycerin makes it more pliable and manageable. It is applied by cutting strips and moistening the glazed surface with a damp sponge. In every other respect the same details are to be observed as in the use of the adhesive plaster.

Collodion.—This agent, introduced as a surgical dressing by Dr. Maynard, of Boston, consists of a solution of gun-cotton in ether and alcohol, and should be kept in glass-stoppered bottles. It is best employed after the plan of the late Dr. Paul B. Goddard, by cutting strips of soft silk gauze and attaching them first to one side of the wound by brushing the collodion over each with a camel's-hair brush. In a short time—which may be shortened by blowing upon them—the ether evaporates, leaving a thin film, which glues the strips to the surface, after which the wound is drawn together, and so held by bringing the other ends of the strips across and uniting them to the opposite side. The liquid should not be allowed to touch the raw surface, as it acts the part of an irritant. This dressing is not acted on by moisture. After the approximation the wound may be sealed up from the air by brushing the collodion freely over all. Collodion is sometimes mixed with tannin (Richardson's "*styptic colloid*"). Where there is an oozing of blood it favors coagulation, and forms a crust or scab, which tends to exclude the air. The addition of carbolic acid, salicylic acid, or bichromate of potash, with a view to their antiseptic effects, promises very little good indeed. Dr. Hewson has been in the habit of using lead ribbon with collodion instead of gauze, particularly in wounds of the scalp. Numerous slits are made in the lead to serve the purpose of the apertures in the gauze. The collodion dressing can be removed by moistening with alcohol.

Court-plaster.—This plaster is prepared by brushing over silk a solution of isinglass and gum benzoin in spirits of wine, and then giving a coating of Chian turpentine. A better variety, one less irritating, is that made from dissolved *caoutchouc* applied to silk. This is applied by moistening the surface with warm water, and is well suited to slight wounds of a superficial nature.

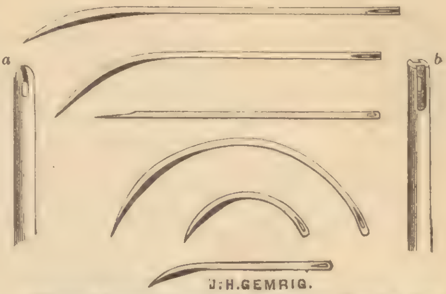
Skin plasters.—These are made from the intestine of the sheep or the peritoneum of the bullock, and have a very limited use. They answer well for closing the lids of the eye after the operation for cataract, or for covering excoriated surfaces. To render their application practicable, the dry skin must be first laid in position and then brushed over with a wet camel's-hair brush.

SUTURES.—The sutures in common use are four in number,—the *interrupted*, the *continued*, the *twisted*, and the *quilled*. The depth to which they should be inserted must be determined by the depth of the wound. If very superficial, they should be only through the skin; if deeper, well into the subcutaneous tissue; the object being in all cases to bring into close apposition the entire thickness or depth of the wound, and to prevent gaping. All interspaces permit oozing and the collection of purulent matters. Their distance of entrance and exit from the margins of the wound should be from one-eighth to three-eighths of an inch, though sometimes, as in the treatment of lacerations of the female perineum, it is required to exceed one inch. In their insertion they should be carried from without inwards through one side, across the wound, and from within outwards through the opposite side.

The *interrupted suture* is the one most generally employed, and requires for its application a needle, straight or curved, and a thread of silk, silver, iron, lead, or horse-hair. In my experience, the most imperfect instrument made

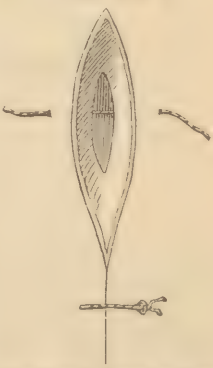
by American surgical cutlers is this needle. Whatever be its form, the cutting end should be spear-shaped, should extend but a short distance back from the point, and should exceed in its transverse diameter that of the shank or thread extremity of the instrument. The eye should be as large as possible, well rounded, so as not to cut the thread, and, when wire is used, countersunk, so that the thread will not project above the common surface, thus removing one great obstacle to its easy passage. (Fig. 129.) There are modifications of the needle suited to special operations, which will be treated of in their appropriate places. A needle after being used should be cleansed in carbolic acid water, a precaution too often overlooked, and the neglect of which may make it the bearer of infection. The introduction of the first suture is usually across the middle of a wound, unless there are projecting points or angles, when it will be proper to connect these first, that correspondence of the margins may be insured. After its insertion, each thread is cut off at a convenient length, and the process is repeated until a sufficient number are in place, leaving, as in the application of adhesive plaster, proper intervals between for drainage. Ordinarily each suture is secured as it is inserted, observing to bring the edges accurately in contact, but not so tightly as to pucker and produce strangulation. The knot may be either a double reef or bow, the latter admitting of being tightened, if necessary, and should always be made at the point of entrance or of exit,—never over the line of approximation. (Fig. 130.) In extensive wounds the sutures may be placed one inch apart, and be supplemented by adhesive strips between. The wire thread is made fast by simply twisting the ends about each other, or by passing them through a perforated shot (Fig. 131) and compressing the latter by a pair of strong forceps. (Fig. 132.) This shot-clamp is well suited to secure the hair thread.

FIG. 129.



Different forms of surgical needles: *a* showing the oblong eye, and *b* the countersunk eye, by which the wire can be placed below the surface of the needle.

FIG. 130.

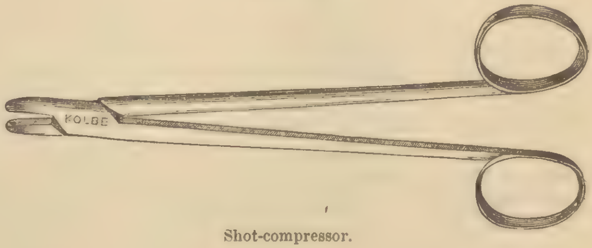


Interrupted thread suture introduced and knotted.

FIG. 131.

Wire thread clamped with a pellet of shot.

FIG. 132.

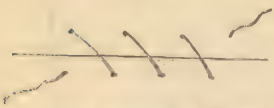


Shot-compressor.

The time for the removal of sutures, save in exceptional cases, is usually from the third to the fourth day: after this they become sources of irrita-

tion. The metallic thread may, if it is deemed necessary, remain longer, as it generally excites less inflammatory disturbance in the tissues, and indeed is found so superior to the old silk thread suture as in most instances to have displaced it. There are, however, localities, as, for example, the eyelids, in which the parts are so delicate and extensible that the apposition is made more satisfactorily by silk. In removing the metallic thread properly, great skill is required. It should be cut on one side and the hook-like end straightened, after which, the twist being seized by the forceps and the blade of the scissors placed against the inside of the undivided end, it is made to revolve about the latter as it is withdrawn.

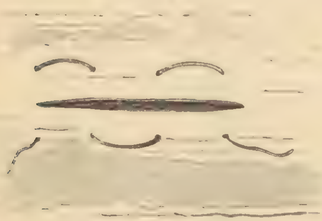
Fig. 133.



Diagonal, continued, or glover's suture.

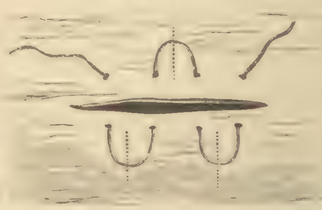
The continued suture.—This is not often resorted to. It is called the glover's suture. It is applied in two ways,—over and over diagonally (Fig. 133), and from side to side without crossing over the wound (Fig. 134). By the last method, if a loose loop be allowed on each side, an interrupted suture may be quickly made by dividing the loops (as in Fig. 135). The uninterrupted or continuous suture is used in intestinal wounds.

Fig. 134.



From side to side.

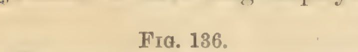
Fig. 135.



Making an interrupted suture out of a continuous one by cutting the loops in the position of the dotted lines.

The *twisted suture* is used in cases where it is desirable to bring divided surfaces into firm contact in order to prevent bleeding. It is generally used in the treatment of hare-lip. To make this suture, it is necessary to provide needles or pins, thread, and a pair of cutting pliers. Some use the ordinary sewing-needle, surmounting it with a glass head; others use the common insect-pin; and others, again, a silver pin with a steel point, which can be disengaged after the former is in place. None of these is free from objection. I have long employed a very slender and finely-pointed steel pin of considerable length surmounted with a large glass or wax head. (Fig. 136.) Such a pin is managed with certainty, and passes through the tissues with scarcely any resistance, enabling us to dispense entirely with needle- or pin-holders. Professor Gross is partial to a fine gold pin, especially in wounds of the face, where it is desirable to prevent a scar.

Fig. 136.

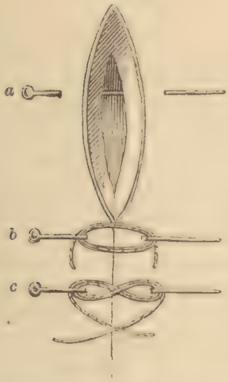


Pin for twisted suture.

In applying this suture, the pins should be passed obliquely through the sides of the wound; on one side from without inwards, and on the opposite from within outwards, the entrance and exit being from one-quarter to half an inch distant from the edges. The distance between the pins must be determined by the necessities of each case, and the depth be sufficiently great to pass below the vessels of the sides. The pins in place, waxed threads are passed several times around each one, elliptically, or often in the form of the figure 8, and drawn with sufficient firmness to bring in contact the surfaces of the wound, after which they are secured by a knot. (Fig. 137.) Sometimes a long thread is used, and passed from pin to pin. I am not aware that the method possesses any advantages whatever: indeed, I consider the procedure unsurgical, as it obstructs the intermediate spaces and prevents

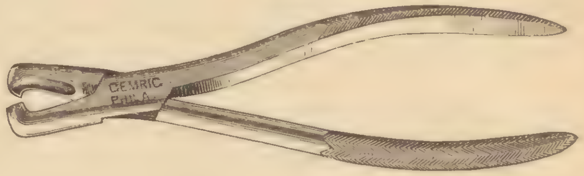
drainage. The pliers (Fig. 138) are next brought into requisition, the pointed extremities of the pins cut off, and, to prevent undue pressure, a strip of adhesive plaster may be passed beneath their extremities.

Fig. 137.



A wound traversed with three pins: *a*, the pin *in situ*; *b*, the pin with a thread thrown about it; *c*, thread arranged in the form of a figure 8.

Fig. 138.

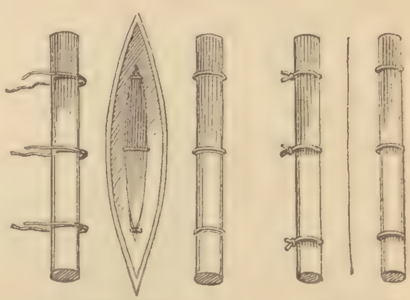


Cutting pliers.

The time for the removal of the pins varies from thirty hours to three days: to effect it, the head should be grasped with a pair of ordinary dressing forceps and gently rotated a few times, after which traction may be conjoined to rotation, when the pin readily becomes disengaged, leaving the loops of threads in position, glued to the parts by the secretions, and where they may be allowed to remain for a day or two longer as a uniting medium.

The *quilled suture* is quite limited in its application, being confined for the most part to the closure of lacerations of the female perineum; and I think that I have proved it to be unnecessary even here.* It takes its name from the little cylinders of plaster, in size and form resembling the ordinary goose-quill, about which the threads were tied. To apply this suture, stout curved needles, armed with double silk threads, are passed through the sides of a wound, from three-quarters of an inch to one inch from their edges; the needles are next disengaged from the free ends of the threads, leaving their loops projecting some distance from the points of entrance. Two pieces of rubber bougie, or two rolls of adhesive plaster, are next placed in a longitudinal direction and parallel with the course of the wound, one piece being carried through the loops, the other laid between the free ends of the sutures. (Fig. 139.) As the latter are tied firmly around the cylinders, the edges are not only drawn together, but also slightly everted. There are other sutures, and instruments for their introduction, which will be described in their appropriate places.

Fig. 139.



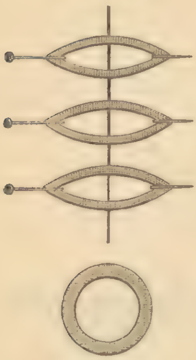
Quilled suture. Wound closed.

The French surgeons were in the habit at one time of approximating wounds by means of serres-fines; but these are productive of more irritation than ordinary sutures, and have little claim to professional notice in this connection.

* Lacerations of the Female Perineum, by the author.

The rubber suture.—This suture, the invention of Rigal, substitutes for the thread of the twisted suture, little rings of gum-elastic. (Fig. 140.) The difficulty in its use arises from an inability to apply the proper amount of pressure, in consequence of which patients complain of a sense of constriction in the parts upon which the rings act.

Fig. 140.



Rubber suture.

After the suturing has been effected, there remains still a very important part of the treatment,—that of removing any remaining blood, excluding the air, and securing entire rest and the close contact of all the parts, superficial and deep. A little gentle pressure will force out whatever oozing may have occurred during the insertion of the stitches, and the application of compresses and a carefully-applied roller will accomplish the rest. The compresses, made out of old linen, muslin, lint, or the paper dressing, should be moistened with carbolated water (one part of carbolic acid and thirty parts of water), and laid over the surface, or, if an additional uniting force be required, two additional compresses, one on either side and parallel with the wound, should be made fast by the roller.

In wounds of the extremities, the roller must begin at the hand or foot and extend some distance above the seat of injury, so as to insure a firm and uniformly-distributed pressure to the muscles and blood-vessels, as well as to obliterate all cavities or recesses beneath the united parts, so that there shall remain no little pockets for the accumulation of blood or pus. This cannot be too strongly insisted upon, controlling as it does muscular and inflammatory action.

After-Treatment of Wounds.—If minute attention has been given to the removal of all irritating substances, the control of bleeding, accurate adjustment, and judicious compression, together with rest, there remains little else for the surgeon to do, save to avoid officious interference. For this reason it is impossible to fix arbitrarily periods for the renewal of dressings. It is always proper to remove the external compresses about the third or fourth day, with a view to ascertain the condition of the parts. If no undue redness, swelling, or suppuration exists, the inference is that all is going on favorably, and the carbolated water should again be applied as in the first instance, the bandage renewed, and not disturbed for two days more. If the wound is extensive, we may expect a certain amount of suppuration, and for this reason it should be inspected daily—even twice a day, if there is much discharge—after the second dressing. Cleanliness is of the first importance, but we should not presume to interfere more than to remove, with a sponge or piece of oakum moistened with warm water, such discharges as have found their way to the surface, or, if there is any evidence of purulent accumulations beneath, to press them out gently. A stream of water from the nozzle of a syringe, or from the hose of a ward carriage, is often preferable to all other means of cleansing a wound. If an adhesive plaster has become detached, it should be replaced by another; or if a suture has cut through, it must be removed, and carbolated water applied as in the first instance. When suppuration is past, and the union has become firm, a piece of linen or lint, spread with simple cerate, Goulard's cerate, or benzoated oxide of zinc ointment, may advantageously replace all other applications.

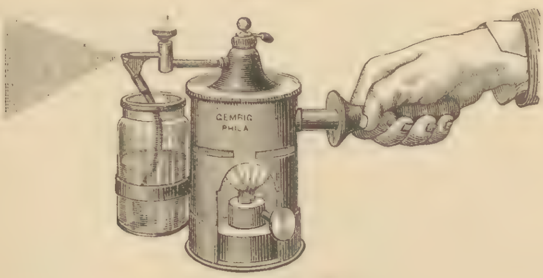
While very good results can be obtained by adhering to the course which has been described, the antiseptic method of Professor Lister for the treatment of wounds, I am convinced, after a trial of one year, possesses advantages over all others. While I have not obtained results so extraordinary as those claimed by this eminent surgeon, the success has been so much more satisfactory than that obtained by the ordinary plans, that to decline

the use of antiseptic dressing would be, in my judgment, to withhold from a patient the benefit of one of the most important resources of the art. By this plan the suppuration is greatly lessened, the union hastened, the risk of constitutional infection diminished, and the surroundings of the patient rendered less prejudicial to health. To carry out this method involves the most scrupulous attention to details. The carbolic acid should be of a pure crystallized quality, and, when so procured, has, as compared with the ordinary article in the market, but little odor. The strength in which it should be used is one part of the acid to thirty or forty parts of water. It is employed in three ways: as a liquid or bath, for instruments and sponges; as a spray, to impregnate the air about a wound and to moisten the wound itself; and as one of the components of a mixture—consisting of carbolic acid one part, resin five parts, and paraffin seven parts—with which to charge a material like gauze or fine crinoline.

The manner of saturating the fibres of the gauze is to melt the mixture in a trough heated by steam, dip the cloth into the liquid, and then pass it between rollers, so as to press out all redundant material. The same end may be attained, but not so perfectly, by subjecting the layers of the gauze to compression.*

In addition to the above, there are required, to complete the antiseptic treatment, a steam atomizer (Fig. 141), oiled silk, and Mackintosh cloth.

FIG. 141.



Lister's steam atomizer.

The last can be obtained at any of the rubber manufactories. The prepared gauze and the Mackintosh cloth can be used over as a dressing a number of times,—the first by boiling in soap and water, drying, and again subjecting it to immersion in the melted mixture of carbolic acid, resin, and paraffin; the Mackintosh requires simply a careful wiping with a sponge moistened in a sud of carbolic acid soap.

The mode of treating a wound antiseptically is as follows. Into a shallow basin containing the carbolic acid water all instruments used in the dressing are placed,—knives, forceps, tenaculum, needles, silver wire, drainage-tubes, and sponges. In the same bath the surgeon and assistants wash their hands. The steam atomizer is adjusted so that the carbolic acid spray shall play around and upon the wound, and also upon the hands of the dressers, like a fine mist. Any vessels requiring ligature are to be lifted by a tenaculum and tied with the catgut thread, both ends of which should then be cut off. The oozing having ceased, the parts are next brought together and secured by the silver wire interrupted suture. Over the line of approximation a strip of the carbolated silk is now laid, the object of which is to prevent the resin of the gauze from adhering to the wound; upon this are next placed two or three layers of the antiseptic gauze, and over all a piece of Mackintosh cloth. A few turns of a roller will serve to secure the dressing to the part.

* Transactions of the International Medical Congress at Philadelphia, 1876, Proceedings of Surgical Section.

During the whole procedure the spray apparatus must be kept in operation. In extensive or deep wounds, a drainage-tube is frequently introduced, to prevent any accumulation taking place. When the wound is to be redressed, which should be in the course of three or four days, the edge of the dressings is to be raised and the spray allowed to penetrate beneath, and, as the former are drawn away, those which are to take their place should immediately follow,—that is, the carbolated silk, gauze, and Mackintosh cloth. In all subsequent dressings the same rigid attention to minutiæ is demanded as at the beginning.

CONSTITUTIONAL TREATMENT.—In extensive wounds, whether made by the knife of the surgeon or by accident, some degree of constitutional disturbance will manifest itself, in the form of dry skin, increased heat, thirst, and accelerated pulse, frequently accompanied with headache and high-colored urine. It may be so slight as to demand but little attention, and, even when well marked, it disappears in two or three days. It is quite sufficient to restrict the diet for that time, allowing only toast-water, barley-water, tapioca, milk, chicken-water, or articles of a similar nature, until the perturbation is overpast, when the diet must be of a more generous kind. Little medicine will be required. A few doses of neutral mixture, or of spirit of nitre largely diluted with cold water, a gentle laxative of Rochelle salt, and an anodyne as soon as the skin becomes moist and the pulse less frequent, will fulfill every indication.

Complications.—From various causes, both local and constitutional, the healing of a wound may be interrupted, or complicated.

1. *Inflammation.*—The edges of a wound may become red, swollen, sensitive, and discharge a sanious fluid,—conditions altogether incompatible with healing. This may occur shortly after the first dressing, or it may set in several days later, in which case the union is dissolved and the parts exhibit a tendency to gape. A diligent search should be made to discover the cause. If the parts have been irritated by motion, absolute rest must be enforced; if some officious intermeddler has suggested an improper application, it should be removed; if the condition is the effect of irregular habits, a mercurial purge, followed by tonics and carefully regulated diet, should be ordered. As a local application nothing answers so well as irrigation with warm water; but lead-water and laudanum, applied by moistening cloths with the liquid, spreading them over the wound, and renewing as often as they become dry, acts very favorably. The retaining roller in such cases should never be made very loose. Should the redness and sensibility not yield to such remedies after thirty-six hours, a few leeches may be used contiguous to the wound. A little blood taken in this way will often change the whole character of the sore in a few hours, as if by magic.

2. The union of a wound may be delayed by *persistent suppuration.* In such cases the failure is referable to a defective constitution of the blood and a tardy local circulation. The pus is generally unhealthy, and often emits an unpleasant odor. This indisposition to heal may be caused by excessive or redundant flaps, allowing hollow spaces beneath. I have seen from this cause amputations of the mammary gland refuse to heal for many weeks after the usual period for union.

The treatment must be directed to the system at large, as well as to the rebellious parts. Quinine and iron, wine, and a nutritious diet, with an anodyne, especially at bedtime if the patient passes restless nights, compose the constitutional measures; while as local agents, the free use of permanganate of potash to deodorize the discharges, stimulating the parts with a dressing of dilute alcohol (one part to eight parts of water), and injecting any pouches with a solution of sulphate of copper (three grains to the ounce of water) or sulphate of zinc of a like strength, answer admirably. Excellent effects are sometimes obtained by injecting water in which a little carbolic acid soap has been dissolved. All such wounds should

be dressed twice daily, and be well supported by accurately-adjusted compresses, to bring in close contact all ununited surfaces and prevent any purulent accumulation.

3. Wounds may be complicated by epidemic influences. Thus, at periods when erysipelas or diphtheria or hospital mortification prevails, the danger is imminent. No wound should be allowed to remain in a ward where these exist. When erysipelas attacks a sore, it is announced by a rigor, the margins are dusky red and very sensitive to the touch, the work of repair is immediately arrested or retrogrades, and the discharges become thinner, diminished in quantity, or ichorous. When the wound is one of some magnitude, the general system will participate profoundly in the complication. The pulse is frequent and feeble; the tongue is dry and covered with a brown crust, with a dry red streak in the middle; the strength rapidly fails; delirium supervenes, and the patient either dies in defiance of the best-directed efforts, or is the subject of a protracted convalescence.

In diphtheritic attacks the wound becomes dry and pale, is covered to a greater or less degree with the peculiar gray, grayish-white, or buff-colored exudation, and there is no attempt at reparation. This is accompanied or followed by rapidly increasing prostration, and the case is converted at once into one of the gravest nature.

When a wound becomes the subject of mortification, there is an end to repair. The edges are swollen, bloodless, and painful; the granulations shrivel up and disappear; the discharges cease, or are greatly perverted, becoming thin, bloody, and of an offensive odor, while the tissues are rapidly converted into a grayish slough. The system sinks into a typhoid condition, and, unless the malady is speedily arrested, the patient soon succumbs to it.

For the most part, these evils have a local origin, and are generally preventable, unless there has been some gross neglect or oversight in regard to the hygienic surroundings of the patient; and the surgeon will do well to consider how far he is responsible for such complications. The statements of Lister of Edinburgh, Thiersch of Leipsic, Nussbaum of Munich, Volkmann of Halle, and other eminent members of the profession, are of so startling a character that they demand the most solemn consideration. In the hospitals under the care of these surgeons erysipelas and gangrene had been for years adding to the mortality of their wards, defeating the best-selected operations and rendering certain others so hopeless as to discourage their performance; but since the introduction of the antiseptic plan in its details, these formidable diseases have been practically banished.

In the treatment of such a complication, first in importance is isolation. These cases, if in a hospital, must at once be removed from the general ward into a separate and well-ventilated apartment; if they occur in private practice, a searching investigation must be instituted to discover the probable sources of infection. This scrutiny must extend to nurses, sponges, dressings, knives, furniture, and even to the medical attendants. A surgeon who is in attendance upon cases of erysipelas, if he is indifferent to change of clothing and personal cleanliness, jeopardizes the life of any patient who comes under his knife. A short time since I lost a case of lithotomy by diphtheritic infection, communicated, I have no doubt, by an assistant who was in attendance on cases of diphtheria.

When a wound is attacked by erysipelas, it will be proper to administer a gentle purge of eight or nine grains of blue mass, which is to be followed in one hour by two or three drachms of Rochelle salt. This will relieve intestinal irritation and correct faulty secretions. After this the tincture of the chloride of iron may be used with great benefit, in conjunction with quinine. Six or eight drops of the former and one grain of the latter may be given every two hours. The diet should consist of nutritious broths free from fat, of milk, and, if the case demands more support, of milk-punch or wine. As a local remedy, the tincture of iron, applied freely with a camel's-hair brush over the inflamed surface and some distance beyond, exercises a

most beneficial effect. Dr. Garretson is partial to a mixture of the tincture of iron, tincture of cinchona and quinia* as a local dressing.

In cases of diphtheritic infection of wounds the treatment in most respects answers to that laid down for erysipelas. Local stimulation by nitrate of silver upon the encrusted surface, and internally, in addition to iron and quinine, the free use of the chlorate of potash and tincture of capsicum, are indicated. If the erysipelatous disease be checked, the redness and tenderness subside; or, if the complication be diphtheritic, the adhering exudation melts away, the granulations become more florid, the discharges grow purulent, and the constructive work is resumed and carried forward to completion.

Should the complication be that of phagedæna, it must be arrested by potent caustics, such as nitric acid or bromine, applied as directed in the treatment of hospital mortification, and the entire mass of disorganized tissue converted into a harmless eschar, the separation of which will be best effected by emollient poultices and the careful use of the forceps and scissors. Tonics, stimulants, and food, with opium to relieve pain, must be given; and after the slough is removed, the granulating surface is to be treated as an ordinary ulcer.

4. *Hemorrhage.*—This may be primary or secondary. If there is a free oozing of blood, elevation of the part, the use of cold, and well-directed pressure, will control it. The bleeding may be due to some vessel which has been overlooked at the first dressing, in which case it will occur a few hours after the closure of the wound. Should the dressings become soaked and the flaps distended with fluid and clotted blood, a sense of local warmth is experienced by the patient. Under such circumstances the wound must be opened, all clots removed, and a ligature placed on the vessel. When hemorrhage occurs after the lapse of several days, it may be caused by an unhealthy condition of the wound, in which repair ceases and ulceration destroys the tissues, thus opening a vessel. A frightful loss of blood often takes place in this way. It is an exceedingly unpromising task to cut into the half-decomposed tissues and ligate the offending artery, for in a few days the thread comes away, before occlusion is effected, and the bleeding is repeated. It is better to apply well-directed compression, and, that failing, to use acupressure, or secure the principal vessel at a proper point above.

5. *Muscular spasms*, which sometimes follow wounds, may be due to an irritable condition of the system, or to injury of nerves. This distressing complication must be promptly subdued, as nothing proves more inimical to healing. The application of a roller alone will often answer every purpose, or, that failing, the hypodermic injection of morphia, conjoined with a comfortable position of the part, and in some cases the use of a splint to insure perfect rest.

6. *Sinuses and fistulous tracts* often delay the healing for a long time. These may result from redundant flaps in operations, imperfect drainage, want of accurate contact between divided surfaces, or the movements of underlying muscles. If from the first cause, the simplest and most expeditious remedy is abridgment; if from the second, counter-openings or a drainage-tube; if from the third, injections of sulphate of copper or carbolic acid, with uniform pressure by compress and roller; and if from the last, subcutaneous or open division of the offending muscles, with absolute rest.

7. *Maggots.*—These result from the deposition of ova by flies. There are numerous articles which serve to destroy these bodies, such as sweet oil, spirits of turpentine, etc. Turpentine, however, though very effective, is too irritating. Nothing answers better than pouring into the wound melted lard, cooled sufficiently to be borne without pain, which destroys the animals by entering the respiratory apertures which are near the tail. The antiseptic treatment of wounds will effectually prevent their presence, and is

* Garretson, Oral Surgery, 2d edition, p. 930.

particularly indicated as a dressing in hot climates, where maggots are so prone to infest sores.

Incised Wounds.

Incised wounds may be open or subcutaneous, and are made by sharp instruments,—sometimes by accident, at other times by the knife of the operator. In extent they vary from a slight cut with a penknife, not extending through the integument, to one several inches in length. The more quickly the cut is inflicted the less acute is the pain. A finger is sometimes severed accidentally by a chisel with very little suffering. A high state of mental excitement will often mask it, as in a fierce street-fight, when many extensive wounds are inflicted without the injured party being aware of their existence. The skin is the most sensitive of all the tissues, from its rich supply of nerves; as a consequence, more pain is experienced in cutting from without inwards than in the opposite direction.

The infliction of a wound, if an open one, is followed very uniformly by the following phenomena: pain, retraction or gaping, and hemorrhage.

The *pain* at first is very acute, but gradually subsides, leaving in its place a certain degree of tenderness. A very great difference exists as to the quality, severity, and duration of pain in different persons,—a difference depending on location and peculiarities of organization. Upon receipt of the injury it is exquisite suffering, subsiding into smarting or burning, and finally soreness or stiffness. A supersensitive condition tends to complicate in some measure the kindly healing of a wound. Pain may entirely disappear, and after an interval of days return, in which case it is an evidence of undue inflammatory disturbance.

The *retraction*, depending on the elasticity of tissues, direction, and muscular relations, must necessarily differ in different localities,—a point which has already been considered in the general observations upon wounds.

The *bleeding* which follows the division of structures will be much or little, according to the size and number of the vessels of the part, the morbid changes present, and diathesis. Inflamed tissues pour out much blood, from over-distention and loss of contractility in the walls of the vessels. This inability to contract is not always due to muscular paralysis of the walls of the offending vessel, but to their union with a non-contractile structure. It is from this cause that dangerous bleedings are occasionally encountered from the tonsils after amputation, their elasticity being destroyed by chalky and other rigid inflammatory deposits. Most of the vessels in a wound cease to bleed by the operation of natural processes.

TREATMENT.—The indications in the treatment of an incised wound are: the arrest of hemorrhage; the removal of all foreign matters which may be present; the apposition of the gaping edges; the application of external dressings; and attention to all the details included in the term *after-treatment*.

1. *The arrest of bleeding* is accomplished by various measures already described. It is well to wait a short time, in order to ascertain to what extent nature will aid in this work. Though the first gush of blood may be impetuous and profuse, it often quickly diminishes. Elevation of the part, exposure to the cold air, and the local application of cold or pressure, will close many, perhaps all, superficial vessels. Should we find, however, after a reasonable delay, that there are certain arteries which continue to bleed, they must be secured by the ligature, torsion, or acupressure.

2. *The removal of foreign substances.*—These must, when possible, be removed, by the fingers, douche, streams of tepid water, and the forceps. Among foreign bodies we must not overlook blood-clots. These, when present to any great extent, become sources of irritation, and by their decomposition induce inflammation and suppuration.

3. *Approximation.*—In coaptating the edges of a wound, whether by plasters or sutures, the hair should be removed from the vicinity of the injury.

It serves to collect and retain the discharges, and renders the removal of adhesive strips painful.

4. *External dressings.*—If the wound is trifling in extent, a piece of lint, or a pledget of old linen, or of paper dressing, may be wet with cool water, laid over its surface, and made fast by an adhesive strip or a few turns of a roller. If it is extensive, the antiseptic dressing should be adopted in all its details. This embraces the impregnation of the atmosphere of the wound and the wound itself with carbolic acid spray, and the use of carbolated ligatures, antiseptic gauze, and oil-silk, Mackintosh, or gum-cloth (see p. 187). The repetition or renewal of dressings should not be needlessly frequent.

5. *After-treatment.*—The part should now be placed in an easy, elevated position, and kept at rest. It will always be proper to examine the condition of the wound on the third day; and when this is done, the same precautions —in the use of the carbolic acid spray and other appliances—should be observed as in the first dressing. The state of the wound at this first renewal of dressings will generally determine the frequency of subsequent ones. If union seems to have taken place in a good measure, and there is no evidence of accumulation within, and no undue redness, swelling, or tenderness about the edges, the dressing need not be disturbed for three succeeding days; but if there is much suppuration, the removal of the purulent matter becomes imperative, and the dressings should be renewed daily, pressing out all such accumulations, and continuing the antiseptic measures as before.

Should other than antiseptic ligatures be used, they should be withdrawn as soon as they have become sufficiently disengaged from the vessels. If no undue amount of surrounding tissue has been included, those on small vessels can usually be removed from the fourth to the seventh day; but those on vessels like the radial, ulnar, tibial, and femoral, may require from ten to twenty days before they ulcerate through. So also in regard to sutures: as soon as union is assured, or should they cut through one side before adhesion takes place, they must be removed.

Incised wounds are liable to complications of an inflammatory nature, induced sometimes by improper dressings or neglect of rest, at other times resulting from causes acting through the system at large. Whenever inflammation of a common nature is developed, there is an arrest in the work of repair; the edges redden, swell, and tend to separate; a thin, blood-stained fluid is discharged, which soon becomes more purulent. Should the inflammation prove to be erysipelatous, a blush will appear at the margin of the wound, often accompanied by œdema, great tenderness, and a rapid breaking-down of whatever union may have taken place. This may be preceded by a chill or rigor, with an elevation of temperature, followed by acceleration of the circulation, hot, dry skin, headache, parched mouth, and intense thirst.

In the treatment of these complications, the first indications are to secure, if possible, the resolution of the inflammation by removing any source of irritation, such as sutures, to paint the part over with liquid glass, or cover it with pledgets wet with lead-water and laudanum, and to administer a mild cathartic, such as a few grains of blue mass, followed by two or three drachms of Rochelle salt; after which a refrigerant like the neutral mixture may be used. If resolution cannot be effected, recourse must be had to warm-water dressings or a light poultice, in order to favor suppuration, on the establishment of which the local and constitutional disturbances will disappear, when the wound may again be brought together by adhesive strips, with a view to secure the union of the granulating surfaces, observing to cleanse the parts with chlorinated soda and remove any shreds of dead cellular tissue which may be present.

The *subcutaneous* variety of incised wounds embraces all such as are made in the division of tendons, fasciæ, and muscles by the tenotome for the purpose of correcting deformities, congenital or otherwise, or of securing quiet to some indolent ulcer. There are present, in such cases, the usual phenomena of open incised wounds,—namely, pain, retraction, and hemorrhage,—although

they are considerably modified. The pain is not great, as the opening made in the integument is very small, and the hemorrhage is not very profuse, unless there has been an unwarrantable or careless use of the knife. The almost entire exclusion of the atmosphere, and, of course, of the minute organisms which it contains, conduces to rapid healing. Hence, while a certain degree of tenderness and swelling may follow, the inflammatory symptoms are for the most part slight and the repair rapid. The dressing of such wounds is reduced to the utmost simplicity, requiring only an adhesive strip over the puncture, a roller, and rest. Should exceptions occur, in which the bleeding proves excessive, the application of cold and pressure will be required; or should the inflammatory symptoms prove severe, the treatment will not differ from that proper to the open variety.

Lacerated and Contused Wounds.

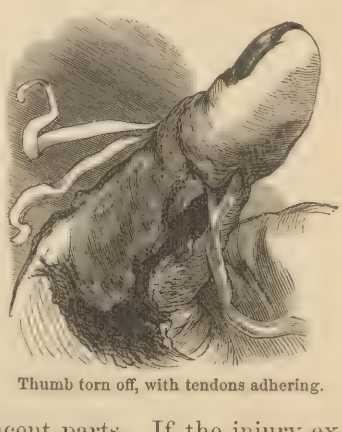
In wounds of this class there is a certain degree of both bruising and tearing, and these two characteristics are so generally present that their consideration under the same head is not inappropriate.

Such wounds are produced in a great variety of ways: for example, by a blow from a bludgeon, from fragments of blasted rocks, by the horn of an enraged animal, a fall against a curbstone, or the passage of a wagon-, carriage-, or car-wheel. The increase of manufactories, the introduction of mowers and reapers, the multiplication of machine-shops and steam-mills, together with the many other labor-saving mechanisms which belong to our modern civilization, all are calculated to add to the number of these wounds.

There is a form of laceration which is called *brush-burn*, made by friction, as when a part is pressed against the belting of machinery in rapid motion, or when a person allows a rope to slip rapidly through the closed hand. I have seen it produced by a large mass of ice falling from a height and striking the body in such a manner as to glide with great velocity over the surface. The heat developed produces an injury not unlike a burn, and the skin in severe cases sloughs.

Contused wounds are seen of all degrees, from a mere bruise of a finger to the complete evulsion of a limb from the trunk, or the pulpification of the entire body. An extremity becoming entangled with belting or drawn into the cogs of revolving wheels presents a frightful mutilation of structure. The skin is torn, retracted, and discolored with lubricating oils; the muscles are riven asunder, pulpified, deeply stained with blood-clots, and have fragments of clothing and bone ground into their substance; while the tendons, torn away from their attachments, hang in coiled cords or are slit into shreds, as seen in the case illustrated by Fig. 142, where a thumb has been caught and torn away from its metacarpal connections, carrying with it the three tendons from their muscular insertions.

Fig. 142.



Thumb torn off, with tendons adhering.

Contused and lacerated wounds possess certain characteristics which are very unlike those of the incised variety.

1. The edges of the former are irregular, hanging in points or ragged flaps, discolored by a purple ecchymosis, cold, and often separated to a considerable extent from the subjacent parts. If the injury extends into the muscles, they are dark and swollen, reeking with blood-stained fluids, and have a bruised and broken appearance.

2. The pain, instead of being sharp and severe as in incised wounds, is slight or is of a dull nature, often accompanied with some degree of numb-

ness. This is particularly noticeable in cases where the injury has been the work of an instant and the force irresistible. The nerves, participating in the bruising and crushing in common with other parts, are incapable of transmitting impressions, which explains the lack of sensibility. In some of the more simple cases of this form of injury, as in the contusion of a finger, the pain is often very severe.

3. These wounds usually bleed very little, even though arteries and veins the size of the femoral, brachial, or axillary be torn. I have seen the arm wrenched from the body, dangling only by a few strips of integument, and yet no bleeding take place. Generally, however, when trunks of the magnitude of those above mentioned are divided, there is considerable oozing,—sufficient, indeed, to make a serious impression on the strength of the patient; and this fact should never be lost sight of. The absence of active hemorrhage is the result of the manner in which the violence deals with the vessels. It is usually the conjoined action of crushing or mashing, and torsion or twisting, by which the internal and middle coats are broken, and turned or curled inwards. The vessel is also drawn into its loose sheath of cellular tissue, the fibres of which close over the orifice. The mechanical obstruction of these fragments of broken tissue is quite sufficient to resist any free escape of blood and favor the formation of a thrombus. In injuries of this kind sufficiently extensive to produce the constitutional state of "shock," the consequent lessening of the contractile power of the heart gives a further security against hemorrhage, as the blood is not propelled along the vessels with sufficient force to dislodge the thrombus.

While it is true that there is an absence of free bleeding at the time of the reception of a lacerated wound, it is equally true that this injury is often followed by secondary hemorrhage. This may occur a few hours after the accident, when reaction has taken place and the heart has regained sufficient vigor to urge forward the blood with power enough to disturb or displace the clots at the mouths of the torn arteries; or it may break out later, from the fifth to the fourteenth day, in which case it is the result of the separation of sloughs. The prudent practitioner will be on the alert for both of these contingencies.

4. Contused and lacerated wounds are prone to slough. The damage done to the vessels, nerves, and other structures disqualifies them for carrying blood or executing the work of innervation, in consequence of which the nutrition is either greatly impaired or destroyed, so that they fall into decomposition and perish.

5. In the healing of contused and lacerated wounds there is a larger surface of granulation-tissue, and a more abundant and protracted suppuration, than in other varieties. This condition follows from the necrosis of the injured parts, portions of which must be separated and extruded in the form of particles, fragments, and shreds, the lifeless components of the wound. This separation goes on with varying degrees of rapidity, according to the structure involved. Muscle quickly disappears, so also do the skin and fat; but dense fasciæ and tendons yield very tardily. The more readily a part, from the looseness of its texture, can be penetrated by migrated leucocytes, the more quickly can it be removed. The final separation, or disjunction of the dead from the living, is but a repetition of that process which has been already described under the head of mortification, and involves the processes of inflammation and suppuration.

The *constitutional symptoms* of extensive contused and lacerated wounds are often very marked, consisting of a slow, feeble, irregular pulse, a cool, moist skin, a pale countenance, with great prostration, and mental alarm. In this combination of phenomena we have the equivalent of "shock." Even in cases unattended by shock it is not uncommon to have some fever present after the lapse of two or three days. This is perhaps of an infective nature, from the absorption of the sewage resulting from dead and dying particles of damaged structure, and may be inaugurated by a rigor or chill, followed by

increase of temperature. This is traumatic or surgical fever. We may also have after its subsidence, and when suppuration becomes established, a repetition of the febrile disturbance.

Prognosis.—In wounds of this class, of moderate extent, a favorable termination may be confidently anticipated; but they are by no means exempt from danger even when simple. The presence of those matters which result from decomposing particles may be followed by fatal consequences. Their entrance into the absorbents may induce ichorrhæmia or pyæmia. I have seen a hospital patient with a simple contused finger die from this cause. The danger from this source is undoubtedly far greater before granulations have formed,—that is, during the work of separation,—probably because when repair has commenced a line of defense has been established by the surrounding wall of tissue.

But there is another peril which may follow, even when the whole surface is covered with healthy granulations, especially should the part be exposed to a current of cold air, or the body to influences liable to provoke a chill; and that is tetanus. I view with horror the surgeon who dresses a healing wound while a draught of cold air is blowing upon it.

A poor man was in the habit of coming to my office to have a contused wound of the hand dressed. All the dead parts had separated, and the part was filling up with granulation-tissue; his general health was excellent, and the ulcer presented nothing peculiar. In crossing the river in one of the ferry-boats, on a cold, raw day, he unwittingly took refuge in the ladies' cabin, and was rudely compelled to withdraw. Standing upon the deck, he became cold and finally chilled. That evening he was attacked by tetanus and died.

A manufacturer who had suffered from a lacerated wound of the hand had recovered sufficiently to leave his house and visit his place of business. On returning home in a street-car, his hand, which had still a small open granulating surface, was allowed to lie on the ledge of an open window. It became cold, and this was followed by a rigor, culminating in an attack of tetanus, from which he recovered only after several weeks.

There is another complication which must not be lost sight of, namely, sloughing. This may be very limited and superficial, confined to shreds of integument; or, if the injury includes the deep structures, it may prove more extensive. Deep suppuration, either before or simultaneous with the sloughing, may occur, dissecting the components of the part and increasing the disorganization. The most alarming form of mortification is that termed traumatic, in which the entire limb may fall into decomposition, and which shows no tendency to establish a line of demarkation. Such cases are often seen after railroad accidents, and betoken extensive destruction of blood-vessels as well as of the other constituents of the part. The limb not only becomes rapidly black, but is also filled with the liquid products of decomposition. Such a condition may follow even when the visible signs of the injury appear limited.

A patient was brought into the University Hospital with a contused and lacerated wound of the forearm. The injury appeared to be confined to this part of the extremity; yet in less than twelve hours the entire limb to the shoulder passed into a state of mortification, from which he rapidly sank and died. It is not an easy task to account for such sudden and wide-spread destruction without admitting some constitutional peculiarity, induced by "shock," in addition to the local injury. I am quite certain that in some instances the determining cause has been the existence of diseased kidneys. Many of the cases of this kind which I have seen have been in persons who drank freely, and in whom, if examination had been made, structural alterations of these organs would have been discovered.

It is impossible in wounds of this class to know precisely the extent of damage to the vessels; and hence the surgeon should be on his guard for secondary hemorrhage.

In lacerated wounds in the neighborhood of tendons, as at the wrist, hand,

or foot, the prognosis should be reserved. There is a tendency to thecal or bursal inflammation and suppuration, which may spread like a conflagration, and utterly disorganize the part.

A patient entered the University Hospital during the winter of 1875, who had some time previously received a contusion of the thumb. The inflammation at the time of his admission had traversed all the thecal sacs and canals of the hand, terminating in the diffusion of pus beneath the palmar aponeurosis in every direction.

Treatment.—The indications are the same as in the treatment of incised wounds.

1. *The arrest of hemorrhage.*—Though in the class of wounds under consideration we do not encounter impetuous bleeding, yet there is a quiet leakage going on which will in time tell seriously upon the patient's strength. Should this come from small vessels, a little pressure will control it. A careful search should be made where there is reason to believe that large trunks have been damaged; and should it prove that such is the case, they should be tied with ligatures, whether bleeding or not, to render them secure against the effects of reaction.

2. *The removal of foreign bodies.*—Whatever these may be, they should be carefully extracted. Sometimes dirt or gravel is ground into the wound by the wheels of a wagon or by falling masses of rocks: this should be washed out by a douche of warm water from a sponge held some distance above the part, or by a stream from the nozzle of a syringe. Sometimes portions of the clothing, blackened with tar or grease, or fragments of glass, are forced into the midst of the broken structures: in this case the forceps or fingers will be found the most convenient and effective instruments for their removal. Even the natural components of the part may, after such accidents, become foreign, and demand removal with as much urgency as those which enter from without: thus, portions of integument hanging by a thread, pieces of detached muscles, and comminuted fragments of bone, having lost all vital connection with the wound, are to be taken away. Just here it is proper to introduce a caution in regard to taking too much liberty with ragged portions of structure. It is often very difficult to decide with certainty what will be the fate of irregular and partially separated flaps of integument. Some very unpromising tags do survive; and therefore the knife or scissors should be used sparingly, and when the least uncertainty exists it is better to give the patient the benefit of the doubt, and allow such shreds to remain: if they survive, well; if not, no harm will come of their being left to the process of natural separation. In all wounds about the face and scalp this rule applies with tenfold force, in consequence of the great vascularity of the tissues. In dealing with fragments of bone, we may hope to obtain their reunion so long as their periosteal connection with the shaft remains.

3. *The apposition.*—Wounds of this kind, being prone to slough, from their diminished vitality, will not endure tension or stretching, and when their sides can be placed in contact it is better to avoid stitches and simply apply adhesive strips, leaving ample intermediate spaces for drainage. If there is a tendency to displacement, the angles or processes of the margins should be loosely united by inserting a few stitches of silver thread. As preliminary to the use of either sutures or plasters, the parts should be cleanly shaven of hair.

4. *External dressings.*—In applying an external dressing the antiseptic method of Lister may be adopted, or simply water may be used. In wounds of this kind I confess to a great fondness for water. Some of the grandest triumphs of conservative surgery, especially about the hands, have been obtained by means of water-dressings. If the wound is small, it will be sufficient to apply wet compresses, renewing them from time to time as they become warm and dry; but in more extensive injuries of this nature I much prefer to employ irrigation (as shown at page 69). The temperature of the fluid must be regulated in accordance with the extent of damage sustained

by the soft parts. If their temperature and color are good, it may be employed cold; if not, it must be cool or lukewarm,—otherwise the circulation and innervation, already feeble, may be so depressed as to induce sloughing. Water used in this manner moderates the local vascular disturbance and washes away serous, purulent, and other products from the wound. The water may be advantageously medicated with chlorinated soda, permanganate of potash, salicylic acid, or carbolic acid, all of which have the effect of deodorizing and rendering innocuous the putrid formations in the wound, and of destroying such atmospheric organisms as are believed to promote suppuration. During the separation of any dead portions of the wound and the establishment of suppuration, the temperature of the water may be raised a few degrees, by which an increased amount of blood will be invited to the part, and those capillary activities of transudation and suppuration maintained which are necessary for the separation of the dead from the living. Should an inflammatory infiltration ensue, stuffing the parts with blood-stained serum, and threatening to strangulate by its accumulation the structures in the midst of which it extends, incisions will be demanded, which by emptying the surcharged tissues may limit if not arrest mortification.

When the sloughs begin to loosen, the vigilance of the surgeon should be increased in anticipation of secondary hemorrhage, particularly in deep wounds and in the vicinity of large vessels. Both patient and nurses must be carefully instructed how to act in the event of such an occurrence. Let the directions on this important point be clear and well impressed: otherwise lives will often be lost during the terror and disorder which an angry outbreak of blood produces. The means to be adopted in such cases is pressure over the main arterial trunk of the limb, as the femoral in the leg, or the brachial in the arm. I often direct, in view of such emergencies, the loose adjustment of a tourniquet, which can be screwed down at the first signal of danger. A profuse bleeding originating in this way may cease from syncope or exhaustion or the formation of a precarious clot before the arrival of the surgeon, and he may be betrayed into a dangerous error by supposing that the storm is past. The probabilities are that when the heart recovers its power the bleeding will be repeated, and with these alternations of cessation and renewal the life of the patient will slip away from professional timidity and indecision. It is proper, then, in all cases where we have reason to believe that a large vessel is opened, to make the ligature of the chief artery of the limb at once. To seek for it in the wound, even were it found and ligated, would only be to expose the patient to the liability of a repetition of the accident, the parts being in an unhealthy and sloughing condition.

After the sloughs are all removed, the work of granulation begins in order to repair the breach. These granulations are open to all the accidents of ulcers, and should be treated on the same principles. Irrigation may be suspended as soon as cicatrization begins, and the healing surface covered by a pledget wet with plain water, and, as the cicatrization advances, this may be substituted by a dressing of simple or Goulard's cerate.

The discolorations or ecchymoses which frequently exist around a wound require time for their removal, though the work may be hastened by stimulating lotions,—the best, in my judgment, being dilute alcohol in which a little muriate of ammonia is dissolved (five grains to the ounce), and applied by wetting pledgets of linen with the fluid. Spirit of camphor is a popular domestic remedy, and so also is the tincture of arnica, both of which answer a very good purpose.

Constitutional Treatment.—In cases attended with shock, should reaction not soon occur, external warmth must be applied to the extremities, spine, and epigastrium, and warm milk or beef-tea, with a little wine or whisky, given at intervals; though stimulants should be exhibited with caution, and not prematurely. After reaction, pain and nervous excitement, when present, are most easily relieved by opiates,—the best being the deodorized tincture of

opium by the mouth, or morphia hypodermically. During the febrile state, the administration of cold drinks, with a little sweet spirit of nitre, an occasional laxative, and an unirritating but nutritious diet, constitutes all the necessary treatment.

Should traumatic mortification set in, all our resources must be brought forward to counteract the accompanying exhaustion, such as milk-punch, beef-essence, eggs, substantial broths, chicken-jelly, and beef-jelly. If the stomach becomes irritable, with a tendency to nausea or vomiting, champagne or carbonic acid water will be useful. Pain and restlessness are best controlled by anodynes, and quinine and iron become valuable as tonics.

Contused Wounds.

Contusions are concealed wounds, and possess many features of great interest. They are produced in a variety of ways,—by blows, falls, or forcible pressure, as when a person is crushed under falling timbers or walls or is caught between the buffers of cars. These injuries are met with in various degrees of severity, from a slight bruise or pinch of the skin, followed by a little discoloration, to the pulpification of all the components of a limb or the rupture of fasciæ and blood-vessels and the laceration of internal organs, such as the spinal cord, brain, liver, spleen, intestines, and bladder. It is almost incredible what an amount of damage can be done to the deep-seated parts without even a lesion of the skin. Many persons, especially aged women, who are emaciated, are particularly affected by such injuries,—the slightest blow, or pressure with the fingers, giving rise to ecchymosis. In scorbutic states of the system the same tendency exists.

The *symptoms* of a contusion are pain, swelling, discoloration, and, in severe cases, "shock."

The *pain* experienced after a blow is not intense or acute. It is described as a numbness or dead feeling, which may remain for a long time, or end in a tingling or pricking sensation, especially if the trunk of a nerve has been bruised. When the violence has been inflicted over portions of the skeleton having but a thin covering of soft parts, like the tibia, and where the periosteum has been injured, the pain merges into a condition of extreme tenderness, the parts becoming intolerant to the slightest pressure. The same violence which originates the pain produces often a loss of power. If a severe blow be inflicted over the deltoid, or across the arm, the limb falls powerless by the side. The contusion may be produced indirectly, as where a person falls upon his feet from a height, and finds himself unable to stand, with defective sensibility in the injured parts. The spinal marrow in such a case has suffered from the transmitted force.

The *swelling* and *discoloration* are closely connected, and are due to the extravasation of blood and blood-stained serum. They occur immediately after the injury, but may not be visible until some time has elapsed. The vessels which furnish the blood are for the most part veins, in consequence of their walls being less able to resist injury. The degree of swelling will depend upon the number or size of the vessels broken and the anatomical structure of the part. Thus, the cellular tissue of the scalp, being compact and inextensible, does not allow of much distention, while the integument of the eyelids, the conjunctiva, and the skin of the penis enlarge to a great extent. The blood which escapes runs through the interstices of the tissues, and may, where no peculiarities of structure exist, spread over an extensive surface, influenced much by gravity, and settling to the most dependent situations; or it may press the fibres of fasciæ aside, compressing them together, and forming a cavity or depot for its reception. These blood-accumulations remain in a fluid state. Such blood-tumors are frequently seen in the scalp of the new-born child, the result of long pressure within the walls of the pelvis, and occasionally follow the application of the forceps when the adjustment is not altogether accurate. Sometimes the swelling arises from a

different cause than blood, illustrations of which are seen in the welts that rise in a few seconds upon the body or limbs of an animal which has been struck with the whip-lash. These enlargements consist for the most part of blood-stained serum which has transuded through the walls of the vessels surcharged with blood under the stimulus of violence.

Discolorations or ecchymoses appearing after the lapse of days are indications of deep-seated injury, the blood—especially the more liquid part of it—finding its way slowly through the planes of structure to the surface. This phenomenon is quite common after fractures.

These ecchymoses exhibit different shades of color, being sometimes quite black, and by an inexperienced eye might readily be mistaken for the beginning of mortification; at other times they are blue, or even red. After a few days these spots may change to a green, yellow, or brown, or a mingled tint in which all are blended. Some of these shades depend upon the relative proportion of the corpuscular and fluid constituents of the blood. The more of the former, especially if from veins, the darker the stain. Should there be a sufficient lesion of the skin to admit air, the color becomes more red, from the action of oxygen. The varied tints or shades in the later stages of ecchymosis must be referred to the decoloration or reaction of hæmatin on the blood-serum present. The ecchymosis present in the profounder parts—as among the muscles—consists of unchanged arterial or venous blood. Ecchymoses are sometimes followed by blebs or vesicles, and, that they may not be confounded with mortification, the following considerations will serve to clear up uncertainty. In mortification, once established, the conditions are absence of pain and sensibility, loss of temperature, crackling from the elimination of gases, and an offensive odor, none of which are present in a case of uncomplicated ecchymosis. If an artery be opened, there is usually a rapid escape of blood, giving rise to a diffuse swelling, which yields after a time a distinct pulsation, forming a spurious aneurism. In the periphery of such a swelling there is coagulated blood, but in the centre it is liquid, and, under the influx of fresh fluid, is kept in a state of motion imitating the circulation.

Blood-swellings are frequently found to become circumscribed after injuries, the circumscription being formed by the condensation of the areolar and other tissues, and this after a time may, through nutritive or inflammatory deposits, assume the character of a membrane or cyst. These "depots," as they are called, are very curious things. The contained blood may assume three conditions,—solid, semi-solid, and liquid. The explanation for these different states I am not prepared to give. I have seen such collections most frequently upon the back and over the gluteal region. The thrombi which form in the labia of the female after a difficult parturition are of this nature. The final disposition of these "depots" is not always the same. Generally they are absorbed, particularly when the blood remains fluid. I have often seen such a termination, even when their great size—equal to the head of a young child—made such an event improbable. They may become sources of irritation, provoke inflammation, and result in suppuration,—a result most likely to take place in those which are hard or coagulated,—and finally they may undergo organization, and pass into connective tissue, in the same manner as does a thrombus within a blood-vessel. I am quite certain that many cysts begin in this way; after the removal of the blood the wall remains, and, being lined by a layer of secreting cells, it furnishes the fluid of the cyst; though it is probable that sometimes the contained fluid is simply the liquor sanguinis of the original effusion, becoming straw-colored or clear by the removal of the formed constituents of the blood.

Results of Contusions.—For the most part, except in aggravated cases, recovery takes place without any unusual drawbacks; yet the effects of contusions are not unfrequently troublesome, and sometimes fatal. The most common sequel is abscess. This may be the result of the succeeding inflammation, and may prove of a diffuse kind, without any limiting wall, as is

often seen in the ischio-rectal region, the scrotum, or the palm of the hand, after a bruise.

Erysipelas may follow a contusion,—oftener seen on the scalp, perhaps, than elsewhere,—and, what is still more serious, *mortification*, limited or extended according to the degree in which the vessels and nerves have been involved.

Cicatricial contraction, especially of the palmar aponeurosis, is another consequence, coming on, it may be, several months after the original injury, and producing great deformity of the fingers.

Hyperæsthesia of a part which has been the subject of a contusion is by no means uncommon, particularly when the injured tissues lie near the bone,—as over the subcutaneous portion of the tibia or the cranial bones. There is frequently associated with this tenderness some induration or thickening, which has its origin in the periosteum. This sensibility may assume a periodical form, an evening exacerbation of pain setting in about bedtime, and often foreshadows the commencement of bone disease. Contusion of joints, when accompanied by comminution of the bones, is a very dangerous injury, often ending in pyæmia and death; and the same may be said of contusions of the liver, kidneys, and spleen.

A bruise is often followed by an intractable *neuralgia*, consequent upon direct nerve-injury, or it may induce in the same manner a localized paralysis.

Fatty tumors I have seen spring up in the seat of an old contusion. *Malignant disease* is frequently called into activity in this way. In very many instances I have known cancer of the female breast rapidly develop after a blow, accidental or otherwise, upon the gland.

When a diathesis is present,—such as rheumatism, gout, or syphilis,—bruised parts are pre-eminently liable to morbid attacks. In the case of a young man at present under my care, who is the subject of hereditary syphilis, if his shoe presses moderately hard at any point on the foot, or a finger be slightly pinched, it is almost certain to produce an ulceration. As far as my observation extends, such results are more common in transmitted than in acquired syphilis.

Treatment.—The arrest of the extravasation is the first indication, though often this has ceased spontaneously before the patient is seen; the second is to hasten the removal of the blood already effused, and to limit the consequent traumatic inflammation.

The measures for the arrest of bleeding consist in applications of cold, as ice in rubber bags or bladders, or ice-water, applied by saturating pledgets of linen or muslin, binding them firmly upon the part, and renewing them frequently, or as often as they become dry. The same caution is proper here as in contused and lacerated wounds,—namely, not to carry the cold treatment too far when the damage has been so extensive as to render sloughing probable; otherwise that event, through the depressing effect of a low temperature, may be brought about unexpectedly. Astringents and stimulating lotions conjoined are valuable remedies, not only for controlling or limiting extravasation, but also for hastening its removal, which is ordinarily a slow process at best. Among this class of remedies I know of nothing so efficacious as a mixture consisting of common table-salt three drachms, muriate of ammonia one drachm, and bay-water six ounces. Pieces of linen or lint wet with the liquid must be applied frequently over the injured parts. Other remedies are in popular use, such as the tincture of arnica pure or diluted, acetate of lead, sulphate of zinc, acetic acid, spirit of camphor, and alcohol. These all possess a decided value as sorbefacients, particularly the alcohol, which I frequently employ. It may occasionally be desirable to remove the blood, though such cases are exceptional. It is frequently done among pugilists in the case of black and swollen eyelids, and the practice is worthy of imitation where it is an object to get rid of such an ecchymosis quickly. A puncture should be made into the cellular tissue of the lid, just above the eyelashes, and the blood pressed out, after which a pledget wet with ice-water should be bound on, to prevent a further accumulation. Depots of blood are

best left to themselves, or at most should be only moderately compressed by pad and roller. On no consideration should they be opened, except when they have provoked suppuration, as they are prone, when lanced, to behave much after the manner of a cold abscess after its evacuation. Should, however, a necessity arise for their incision, the cavity should be frequently injected with a solution of salicylic or carbolic acid, and compression applied, so as to keep the walls in contact and secure their consolidation. In cases where the vitality of the damaged structures is seriously impaired, the circulation being feeble and embarrassed and the skin cool, warm-water dressings are demanded. To maintain these at the proper temperature they should be covered with oiled silk or rubber-cloth. Should a contusion end in a circumscribed slough, its separation will be hastened by a flaxseed poultice, observing to deodorize and disinfect the dying tissues at each dressing with washes of permanganate of potash, chlorinated soda, or carbolic acid water. In instances of diffused aneurism the treatment must be governed by the magnitude of the vessel wounded. If the lesion involves an artery like the radial, or even the brachial, the proper course will be to cut down upon the vessel and tie its extremities; if the popliteal or femoral, to amputate the limb.

Amputation will become necessary in those cases in which the components of a limb are broken into a pulp, the bones comminuted, and the vessels destroyed, as indicated by loss of temperature and the absence of circulation.

Contusions of the abdominal viscera are frequently met with as the result of falls or of the passage of wheels over this part of the body. The injury is characterized by a slow, feeble pulse, cool skin, torpid bowels, and sometimes retention of urine. In such cases there is nothing comparable to external heat and moisture. A piece of flannel, folded two or three double, should be soaked in hot water or a hot decoction of hops, laid over the abdomen, and carefully covered in with oiled silk or rubber-cloth, in order to prevent evaporation and retain the heat. A light mush or bran poultice answers very much the same end.

Where pain is present in contusions, and is of sufficient importance to demand an anodyne, opium in any of its forms may be administered until relief is obtained. The diet should be regulated according to the necessities of the case. Where dead parts are to be separated, or where profuse suppuration ensues, the system will require support, and therefore the necessity arises for nutritious food, tonics, and perhaps stimulants.

Punctured Wounds.

Punctured wounds are produced by sharp-pointed instruments, such as needles, pins, nails, tacks, glass, thorns, splinters, hooks, dirks, bayonets, swords, and the teeth and horns of animals. Wounds inflicted by the fangs of reptiles, the stings of certain insects, and the suctorial apparatus of others, though punctured, do not properly come under this head, as there is an important element in such, viz., the introduction at the same time of some poison or irritating secretion, which confers upon them their chief importance.

The effect on the tissues is different according to the sharpness of the point of the vulnerating body. If a needle or pin be driven into the body, it enters and acts as a wedge: the break in the continuity of the structures is made by the point, whilst that which follows makes room for itself by crowding or pressing together the parts in which it is lodged. If the point be more blunt, like that of a nail, or of the tooth or horn of an animal, a contusion is added to the puncture; indeed, the contusion precedes the puncture, as the parts are bruised before an entrance is made. When glass or splinters enter the flesh, their irregularities of surface cause some degree of laceration; and if a dagger or a sword inflict the wound, the double or single edge of the weapon produces such incision with puncture.

The serious nature of these wounds is perhaps rather exaggerated. The

surgeon constantly, in his investigations and operations, inflicts such injuries without anticipating any evil consequences. The introduction of the exploring-needle to ascertain the nature of growths and clear up obscure points is a matter of daily practice; during the reign of *acupuncture* parts were made to bristle with needles; the trocar is plunged into the walls of the abdomen, or into the scrotum, as in ascites or hydrocele; long aspiration-needles are thrust through the walls of the chest and into lung-cavities; the seamstress pricks her fingers with needles and pins; and women, under singular psychological caprices, make pincushions of themselves to attract a kind of notoriety; yet in all these wounds how uncommon is it to see the least inconvenience follow! Uncomplicated punctured wounds cannot, in view of such facts, be deemed dangerous. The cause which renders them so should be referred,—1, to the structures wounded; as when nerves, tendons, or blood-vessels are pierced. When a nerve is wounded, and the foreign body remains in its substance, or provokes inflammation and the formation of cicatricial tissue, the injury may be followed by excessive neuralgia, or sensibility of the most distressing kind, or muscular spasms, or even epilepsy and tetanus. Should the offending body enter a tendon or an aponeurosis, in time it excites contraction and consequent deformity. I once removed a needle from the tendon of the long flexor of the thumb, which had been for a long time imbedded, and was producing contraction and spasms of pain. When a needle enters a vessel, the opening closes on its removal, without bleeding; but if a nail or a dagger pierce its walls, aneurism or profuse hemorrhage and death will follow. 2, to foreign matter conveyed into the wound, as may happen in cases of post-mortem examinations: in such a case inflammation of the lymphatics and veins may be set up, and abscess may follow. In this way, too, the surgeon's needle, when not properly cleaned, may become the carrier of a deadly poison. 3, to the addition of laceration, which gives increased importance and possible danger to punctured wounds, because the fluids which result from the devitalized fragments of such lacerations may find their way into the lymphatics, poisoning the blood, and giving rise to a wide-spread constitutional disturbance, like that of ichorrhæmia or pyæmia. 4, to the imprisonment of the inflammatory products, there being no opening for their escape. In the palm of the hand and sole of the foot this is eminently true. I have seen hands hopelessly lost from this cause, and death follow in a colored lad from a splinter wounding the foot.

Substances like needles or pins show a remarkable tendency to wander or change their position in the body, moved, no doubt, by the play of the muscles and tendons. I once removed from the knee-joint a needle, the head of which I discovered in the internal lateral ligament, while the other extremity was fairly within the articulation. It had at a previous date entered the thigh. In the case of the needle referred to above as being in the tendon of the long flexor over the first phalanx of the thumb, it was known to have entered the forearm several months previous.

Bodies less pointed, or irregular on the surface, remain stationary, as the irregularities entangle in the tissues and oppose movement: should their composition prove of an unirritating nature, they may become encysted and remain harmlessly imprisoned in the tissues for an indefinite period of time. There is, however, great uncertainty as to the quiet sojourn of such materials. They are liable to become disturbed and create inflammation and abscess. I have removed portions of glass which for several months had been quiet occupants of the body but at last gave trouble and required excision.

Treatment.—The indications in the treatment of punctured wounds are, the removal of the injuring body; the control of hemorrhage, should any follow; the application of proper dressings; and the relief of pain, or of muscular or other disturbance. The extraction of the foreign body is often a matter of no difficulty, as a portion of it may project from the surface, the fingers or a pair of forceps being all the instruments required for that purpose. The fish-hook is an exception, its barb rendering its removal by

force out of the question without laceration; and therefore, instead of pulling it out, an incision should be made upon its extremity, and the hook pushed forward until disengaged, or it may be driven onward until the point appears, when it may be seized with a pair of forceps and extracted after cutting off the shank with a pair of pin-forceps. Portions of glass sometimes enter the flesh and are buried out of sight, as where a tumbler or bottle is broken in the hand, or where the arm is driven through a window. The introduction of a probe will enable us to localize the body, and its extraction is effected by a pair of long, slender forceps, the ends of the blades being well roughened.

Needles will often foil the best-directed efforts for their removal. They generally break off upon entering the body and quickly pass out of sight. The place of entrance is usually indicated by a dark point. By grasping a duplicature of the integument between the thumb and finger we are often able to feel the body, or to excite some complaint of pricking on the part of the patient. I often have located such substances by pressing the skin at different points in the vicinity of the place of entrance with the rounded extremity of a probe, some uneasiness being expressed when the instrument touched over the situation of the body. The magnet has been used to localize needles and particles of steel, but it is a resource of doubtful utility. The best course is to incise the parts obliquely to the supposed direction of the needle, introduce a probe, and make a gentle and delicate exploration of the wound. Its contact with the body is not difficult of detection, although threads of fasciæ yield a similar sensation and may deceive one not familiar with such operations. Once recognized, it may be easily seized and extracted by the long, slender-bladed forceps.

The hemorrhage in punctured wounds is usually slight, and is readily controlled by a compress wet with cold water and bound over the wound by a roller. The addition of a little laudanum to the water exercises a soothing effect upon the part, and, I doubt not, tends to moderate the succeeding inflammation. When a punctured wound is made over a joint, or in the midst of tendons and strong aponeuroses, elevation, and rest upon a splint, with the use of external cold, in the form of ice, are imperative, and generally give a favorable termination to the case. If important vessels be wounded, giving rise to an amount of bleeding not controllable by ordinary pressure, the wound must be enlarged, and the vessel sought for, and tied at both ends, or, this failing, the principal trunk of the limb must be ligated.

The pain which sometimes follows wounds of this kind should be promptly subdued by adequate doses of opium.

In defiance of the best-directed efforts, inflammation will occasionally follow punctures, particularly when the palm of the hand, the sole of the foot, or the extremity of a finger has been the subject of injury. The danger in such an event is great, and demands both bold and prompt surgery. The disease travels rapidly along the numerous synovial and bursal membranes, and the products of the inflammation—being imprisoned by unyielding walls of fasciæ—will occasion not only dreadful suffering from pressure upon the nerves, but also great structural disorganization. When, therefore, the disease does not yield to elevation of the part and hot fomentations, a free incision must be made so as to give exit to all such accumulations.

The addition of contusion or laceration to a punctured wound increases its gravity. It is very common to meet with cases of dog-bite, or scratches made by the claws of the cat, which prove very obstinate, and are not unfrequently followed by extensive erysipelas, and even sloughing. These are best treated with warm water and laudanum, washing them first with a solution of permanganate of potash.

In cases where inflammatory symptoms follow, attended with marked constitutional disturbance, it will be proper to direct a gentle cathartic, such as Rochelle salt or castor oil, to remove all sources of intestinal irritation, and this should be followed by some febrifuge, like the neutral mixture or sweet

spirit of nitre. The diet at the same time should be restricted; and as the inflammation subsides, medicine may be discontinued, and a more liberal allowance of food directed. When abscesses form and the suppuration proves profuse and prolonged, quinine and iron, together with stimulants and a full diet, become necessary.

Healing.

In the construction of an imposing edifice or some intricate piece of mechanism, it is a delightful and instructive task to observe carefully the materials, and the manner in which the artificer fashions and finally combines them into a symmetrical structure, full of beauty and design; and so, after the surgeon has properly adjusted a wound, he may sit down and become a spectator of one of the most extraordinary works of construction, one which is as far above the masterpieces of human art as God is above man.

Surgeons recognize five methods by which a wound may be repaired: first, *immediate union;* second, *adhesive inflammation;* third, *granulation;* fourth, *union of granulations;* fifth, *scabbing.* The first two are usually included in the term "union by the first intention." In his union by the first intention, John Hunter, as remarked by Mr. Paget, seems to have had in view two conditions: one in which no inflammation and no lymph are present, the union taking place by blood; the other in which coagulated lymph is thrown out. The union by adhesive inflammation corresponds to Mr. Paget's "primary adhesion." Union by granulation answers to the "second intention" of the older authors; union of granulations, to the "third intention;" and union by scabbing or scarring is cicatrization under a crust.

1. *Immediate union.*—This means the direct coalescence or union of divided parts, blood-vessel to blood-vessel, nerve-filament to nerve-filament, connective-tissue fibre to fibre, without any intermediate glue, bond, or ligature of blood or of lymph; no seam or scar; the whole process the work of five or six hours. Mr. McCartney, of Dublin, was the first to describe this mode of healing, and thought it quite common in slight cuts; while Mr. Paget, who adopts the same term, gives it a much wider significance, even extending it in some cases to wounds as large as those resulting from the removal of the mammary gland. It requires an imperial faith to believe that the gaping mouths of hundreds of capillaries, whose diameters do not exceed one three-thousandth of an inch, shall so abut that their canals will become continuous, that muscular fibre will meet its fellow, and all the other disjoined parts return to their former connection. To my mind it is simply impossible. I do not believe that any wound, however slight, and however favorable the local and constitutional conditions may be, ever heals, except through an inflammatory product, called *primary cellular tissue* by Billroth, *granulation-tissue* by Virchow, and *germ-tissue* by Rindfleisch. This tissue may be exceedingly small in quantity, and the antecedent disturbance of the nerves and vessels of the part so inconsiderable as not to attract any special notice: still, such disturbance is present, and quietly works out the result,—that of uniting divided parts.

When a part is severed by a sharp instrument, as previously stated, there will be pain, retraction of tissues, and hemorrhage. If the vessels be small, coagulation takes place, and the flow of blood gradually diminishes, finally ceasing altogether. This coagulation forms between the lips of the wound, and extends some distance on each side into the severed vessels as far as their first collateral branches or inosculations of the capillary net-work. (Fig. 143.) The four succeeding cuts, presenting semi-diagrammatic views of the process of healing, were drawn from microscopic sections by Dr. Shakespeare.

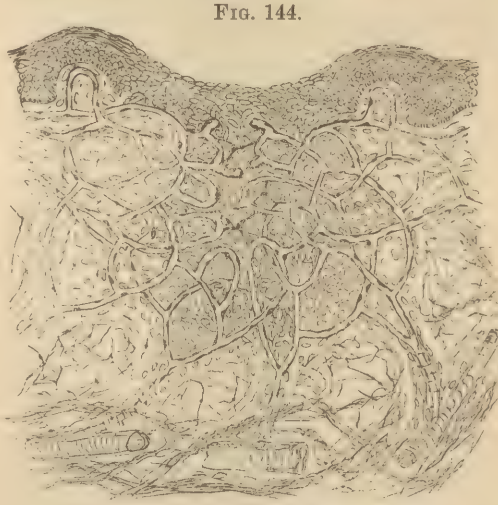
The obstruction of these vessels by clots is equivalent to the loss of so many blood-channels to the circulation, and therefore devolves upon those which remain an additional amount of work. From this cause, and the traumatic irritation, these vessels become distended under the increased blood-pressure, which

gives rise to some degree of redness about the wound. The same cause which crowds these blood-channels with blood-corpuscles determines a transudation of the liquid contents of the vessels and the migration of white corpuscles, so that in addition to the redness there will be some degree of swelling. If we examine sections of a wound twenty-four hours old, the space between its lips and the tissues on either side will be seen filled with large numbers of white corpuscles, which continue to multiply for some time. While this rapid migration of wandering leucocytes is going on, there is a disappearance of the red corpuscles, which, together with the fibrin, formed the clot. A change is also noticeable in the connective tissue of the parts: instead of retaining its fibrous form, it softens and in a great measure disappears. As this disappearance bears a certain relation to the number of cellular forms present, the idea has been advanced that the fibres become the pabulum for these organisms,—a result which is not improbable. Be this as it may, it is certain that after the lapse of twenty hours the wound appears to contain little else than a large accumulation of cells, imbedded in a gelatinous or uniting substance consisting most probably of fibrin and the residue of the former intercellular substance. These cells next undergo a change of form, becoming first oblong and then spindle-shaped. Part of the blood at least which filled up for a certain distance the divided vessels and surrounding parts during this time is gradually being removed by absorption, and a portion probably becomes organized. At this stage, then, the union of the sides of the wound is effected by a bond consisting of cells and a solidifying intercellular substance. This union possesses considerable strength, and is quite sufficient to retain the flaps in contact without any artificial support. (Fig. 144.) Next follows the vascularization of the uniting medium. This is accomplished by outgrowths from the capillary loops on either side of the chasm, which finally meet and coalesce, thus establishing a vascular bond

FIG. 143.

The microscopic appearances of a wound eight hours after its infliction in the integument of a guinea-pig: *a*, the wound slightly gaping, and filled with blood-corpuscles and fibrin, and on each side capillaries similarly filled, the coagula extending also some distance into the sides of the wound; *b*, blood-vessels; *c*, sweat-gland; *d*, a sebaceous gland. The central part of the cut represents capillaries, nerves, and connective tissue.

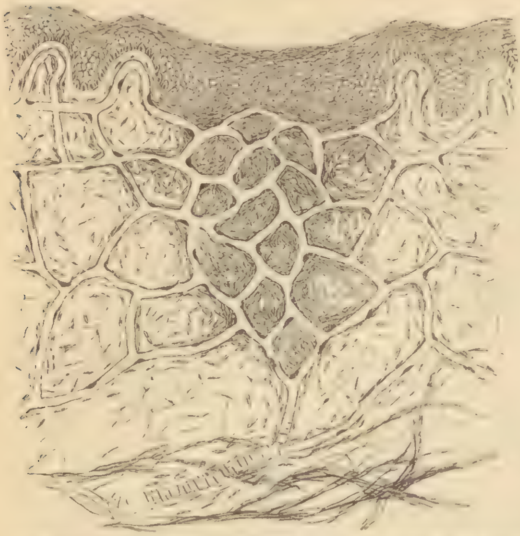
FIG. 144.



The cell infiltration changed into spindle-forms, and, for the most part, the clots from the divided capillaries removed.

between the two sides, by which time the spindle-shaped cells have, with the intercellular substance, reached for the most part the stage of connective tissue. These uniting cells and intercellular substances together with the interpenetrating vessels constitute granulation or reconstructing tissue, and, in my judgment, form the only medium of repair. As there is present a large number of cells bridging over the space between the lips of the wound, so we have also an exceedingly rich plexus of vessels, giving to the young cicatrix a color much redder than that of the contiguous parts. (Fig. 145.) This multiplication of blood-channels serves to relieve the adjoining vessels from over-distention, in consequence of which all undue redness about the margins of the wound disappears. The consumption and reabsorption of the liquid infiltration, and the solidification of the intercellular substance with its fibrillation, remove the swelling, while the absence of pressure from the nerves relieves whatever of tenderness or pain may have lingered about the wound, and thus all the signs of inflammation disappear.

Fig. 145.



The communication of blood-vessels across the wound by a rich plexus and the new connective-tissue bond.

The union being now secure, the uniting materials themselves become the subject of change. The bundles of connective tissue, formed from the spindle-cells and intercellular substance, become more compact, and the rich net-work of vessels in a great measure disappears, or remains not as tubes but as solid threads, like connective tissue, which serve as connecting filaments stretching across the former chasm. There are three explanations for this diminished vascularity: first, the work of repair, though an extraordinary one, demands only for a short time an increased number of channels for the blood, from which reparative materials are derived; second, the formation of vessels to answer a temporary purpose, especially in the early economy of the fœtus, is well known to every embryologist: these, after having met the requirements of the law, gradually

Fig. 146.

The position of the wound occupied by connective tissue, its fibres running somewhat obliquely; the vascular net-work having disappeared.

disappear; third, the compression to which these vessels are subjected by the condensation of the connective tissue must favor their obliteration. As a consequence of the non-vascularization, the cicatrix is rendered paler than the adjoining skin. When the uniting structure is examined, after the loss of its blood-vessel plexus, it presents little else than merely a closely interwoven mesh of connective tissue with attached nuclei, the fibres of the former being disposed obliquely, somewhat like the plume of a quill, rather than directly across the position of the former wound. (Fig. 146.) The effect of this close aggregation and condensation of the new formation, pressing out the serous moisture which usually bathes connective tissue, is to produce contraction and loss of elasticity or suppleness in the bond of union, by which the distance between the sides of a wound is greatly diminished. This tendency to contraction of cicatricial tissue appears to be inherent and continuous, often giving rise to serious evils and deformities, so that it becomes a prime necessity so to condition wounds that there shall be the least possible amount of uniting tissue present.

Healing by granulation is that mode which authors describe as taking place in an open or gaping wound. The granulations rise from the bottom and sides of the chasm, reach the level of the surrounding parts, and then cicatrize or skin over. This mode of repair is like that of an ulcer. If under such circumstances the sides be drawn towards each other, and so maintained, the granulations will unite with each other, diminishing the extent of the gap.

What is a granulation? The answer is very simple. A granulation is a mass of cells, intercellular substance, and blood-vessels. In the union which I have just described in detail—that is to say, *intermediate*, or union by the so-called process of adhesive inflammation—the reparative material consists of cells, intercellular substance, and blood-vessels, which cells pass through oblong and spindle forms into connective-tissue corpuscles. This is neither more nor less than granulation-tissue: so that really there is no difference in the uniting material, but only in the amount present and in its disposition. In the first case, in consequence of the close approximation of the sides of the wound, nothing but a strip or line appears on the surface; whereas in the latter, or union "by granulation," a wide interval exists between the sides of the wound. Let the union advance a few days, and it will be very easy to convert the first into the second by drawing asunder its sides.

Union under a scab is said to take place without granulation. The blood, mixed with dust, dirt, hair, or other foreign materials, hardens into a crust, impervious to air, under which cicatrization goes on without inflammation or the production of granulation-tissue. This is said to be the ruling mode of union in lower animals. If any one will take the trouble to detach the scab before repair is complete, he will see a ruddy surface, sometimes granular in appearance, and although the elevations may be very few in number yet they are nevertheless granulation-tissue.

After examining this subject with no small degree of care, I reiterate the doctrine which I have taught for several years, *that nature follows but one method in the repair of wounds, and that is through cells, intercellular substance, and blood-vessels; in other words, through granulation-tissue, alike present whether the wound be small or great, open or subcutaneous.*

To secure a quick and healthy restoration or union of wounds it is a prime necessity to diminish as much as possible the need for a large amount of granulation-tissue. This is best accomplished by the removal of all blood-clots and other foreign matters, the close and accurate approximation of divided surfaces, absolute rest, and the prevention of excessive vascular disturbance, thus reducing the cicatrix to the smallest possible dimensions.

Ulceration of cicatrices.—Cicatrices often break down from undue pressure, or tension, and occasionally from constitutional causes, as scurvy or alcoholism. These are difficult to heal, often remaining open for years. The management of such ulcers consists in immobilizing the parts; applying stimulants, such as sulphate of copper or nitrate of silver; strapping with adhesive plaster;

grafting; and, should these fail, excision, replacing the diseased with sound tissue when possible. When the ulceration has a constitutional origin it will be necessary to address our remedies to the particular vice in operation, by administering tonics, alteratives, good food, and wholesome air.

Hypertrophy of a cicatrix, or keloid.—This singular change in a cicatrix is occasionally witnessed after operations or in the scars from burns. The change is introduced by the cicatrix becoming ridged up, thickened, rounded, while its vascularity is increased, causing it to assume a bluish, purple, or pinkish color. It frequently becomes very sensitive. A young girl presented herself at the clinic of the University with a keloid growth developed on the site of a former burn. She complained of a burning sensation in the part, and the mere contact of the clothing occasioned great suffering. At her earnest solicitation for temporary relief, it was removed; but it returned, as was expected, in the cicatrix of the wound, though with a diminution of sensibility. Such growths consist of connective tissue and corpuscles in various stages of development. When these hypertrophied cicatrices are free from sensibility they should not be meddled with, as their growth is always limited and they frequently disappear spontaneously. If, on the other hand, they become irritable and painful, a repetition of blisters, followed, on healing, by frictions with iodine or mercurial ointment with which a little extract of belladonna is incorporated, will often prove successful in effecting a cure.

Nodular cicatrices.—These are sometimes called warty, and consist in the elevation of the cicatrix and the subsequent development of irregular knotty masses over its surface. These prominences may break down into ulcers. Though sometimes seen in the cicatrices following the excision of cancerous growths, as in the female mamma, or following the removal of a sarcoma, as in the case of a gentleman now under my care, yet they may be benign and appear in entirely harmless scars. Epithelial cancer is frequently developed from such surfaces.

Painful cicatrices.—Cicatrices may become painful in different ways. A nerve-filament may become compressed by the contraction of its fibres, or a true neuroma may be developed. Such are not uncommon occurrences in stumps following amputations. When the extreme sensibility is the effect of the first condition, a delicate tenotome should be passed beneath the cicatricial tissue and the whole shaved away from its connection with the bone. If it results from the inclusion of a bulbous enlargement of a nerve, nothing will answer but the excision of the cicatrix with the diseased nerve. There are other kinds of cicatricial diseases, independent altogether of wounds, purely subcutaneous, which will be discussed under the head of deformities.

Diseases of cicatricial or scar tissue.—The cicatricial tissue which results from healing is in most respects a delicate structure, much less capable of resisting injurious impressions, either from within or from without, than the surrounding parts, and often the subject of disease.

Spurious cicatrization.—Examples of this defect are often seen in strumous ulcers, or in fistulous openings from either osseous or rectal disease. The surface is of a pale-blue or gray color, concealing the granulating tissue below, and giving a deceptive appearance of healing. A probe readily breaks through, and reveals the true condition as one in which a film of cuticle has formed without the conversion of the granulation-material beneath into fibrous tissue. To correct such a defect it is necessary, if it be a strumous ulcer, to cauterize well with the nitrate of silver and administer constitutional remedies adapted to such a diathesis, as cod-liver oil and the different preparations of the iodide of iron; if it arise from bone disease, the removal of the affected portion will alone effect a solid cicatrization; and if from fistulas in the perineum, communicating with or lying near to the rectum, the remedy lies in these being freely laid open.

Immovable cicatrices.—A cicatrix sometimes adheres to the parts beneath in such a way as to prevent sliding or movement. This is frequently noticed after the healing is completed in bone disease, after amputations, and indeed

to some extent after all wounds, whether accidental or made by the knife of the surgeon. It gives to the cicatrix a depressed appearance. It is most likely to occur when the wound extends through two or more planes of tissue. The loosening of such can take place only by the formation of a soft and open net-work of connective tissue, moist and pliable, in the deep portion of the cicatrix. Time works a great improvement in such cases: indeed, it is the chief element in whatever improvement may follow, though external agents are not without their value,—such as soaking the part in warm water or steaming it, followed by rubbing and kneading. This acts as does pressure on plastic deposits, by securing the removal of a certain amount of intercellular material, and giving a more open or loose texture to the remaining part of the cicatrix. When scars remain intractable to all such measures, and the inconvenience experienced is very great, they may be divided subcutaneously, pressure being used to prevent bleeding: in the course of three or four days motion should be established to prevent the old attachments.

Contraction of cicatrices.—The singular property of contraction possessed by a cicatrix is often productive of the most serious evils. This is seen most frequently after burns, scalds, or the ulceration following excessive mercurialization. The eyelids and lips may be everted, the mouth drawn awry, the chin bound to the breast, the articulations forced out of position. The possibility of such distortions, even in ordinary scars, demands great forethought on the part of the surgeon when planning and executing operations, especially about the face. Unfortunately, we are too often powerless to accomplish much in cases of an extensive nature. Two plans of treatment present themselves,—one that of resisting the contraction by counter-force, as in the case of an extremity, by angular splints moved by a screw, or by attaching weights to the limb, which shall act gently yet continuously, and which will so affect the nutrition of the new formation that the shortening is prevented until the tissue assimilates the characteristics of healthy connective tissue. The second plan consists in removing the cicatrix and supplying its place with healthy integument, either by transplantation or by sliding. When feasible, this proves the more satisfactory method.

Poisoned Wounds.

Poisoned wounds are those which, in addition to a puncture, abrasion, or scratch, have at the time of their infliction some peculiar poisonous or irritating matters introduced into the body capable of producing both local and constitutional disease. In some instances the mere maceration of the skin, without any visible break in its continuity, is sufficient for the reception of the poison. These poisons differ in their nature and in the sources whence they are derived. They may be arranged as follows:

First. Poisons from the bodies of man and beast, both dead and living, the product of disease or of decomposition.

Second. Poisons derived from arachnidans and reptiles, the product of a special poison apparatus.

Third. Poisons derived from insects, formed in the salivary glands.

I shall consider these in their order.

1. Poisoned wounds contracted from the bodies of man and brutes.

Dissection or post-mortem wounds.—These wounds are very much less frequent in Philadelphia at present than they were thirty years ago. As a student I remember suffering myself, and witnessing others suffer, from this class of injuries. Since the introduction of the chloride of zinc as an antiseptic agent these accidents have almost entirely disappeared. This substance appears to possess the property of rendering innocuous the products of morbid cadaveric changes. For several years, while teaching anatomy, during which time my hands were constantly in contact with the fluids of the dead body, no inconvenience was experienced; nor can I recall any case

of dissection-wound among those engaged in the anatomical rooms where the cadavers used had been preserved by the chloride of zinc. Occasionally bodies were injected for lecture-room demonstration with what is popularly known in Philadelphia as "the red mixture,"—a combination of rock salt, nitrate of potash, carbonate of soda, and molasses,—introduced by the late Professor Horner, of the University of Pennsylvania, and which imparts a beautiful red color to the muscles. In several instances I have seen the characteristic poisoning follow a wound inflicted whilst dissecting subjects so treated, and suffered severely in one instance myself.

The bodies of persons who have died from peritonitis, especially when puerperal in its origin, or of those who perish from erysipelas, pyæmia, and carbuncle, are particularly dangerous, in consequence of being charged with irritating, putrid, and septic matters. The risk of infection diminishes as putrefaction advances. Examinations of the body made shortly after death, as in post-mortem cases, are fraught with more danger than those made in ordinary dissections. The state of health at the time of exposure has much to do with the operation of animal poisons. This is corroborated by the fact that when students of medicine receive a poisoned dissecting-wound it is generally towards the termination of the winter session, when the constitutional vigor is somewhat impaired by the combined influences of confinement in lecture-rooms, diminished exercise in the open air, and the enervating effects of badly-ventilated and overheated lodging-apartments. Individuals suffering from organic disease of the kidneys are dangerous subjects for dissecting-wounds. It is also true, as Sir James Paget has observed, that persons long exposed to the atmosphere and duties of the dissecting-room enjoy a certain immunity against the action of the septic materials of the cadaver, just as those living in miasmatic regions after a time become comparatively proof against malarial poisoning.

There are peculiarities of constitution which render some persons particularly liable to suffer either from contact with the fluids of the dead body or from the presence of its offensive exhalations. A prominent surgeon of my acquaintance has on several occasions been as thoroughly poisoned from inhaling the foul odor emanating from the cadaver as though the materies morbi had been placed beneath the skin. In whatever the poison consists, it certainly possesses a power of existence and propagation entirely independent of its origin, as it may be communicated by the blade of a knife used months previously in dissections. The part which generally suffers in wounds of this class is the dorsal surface of the hand, a part where the skin is most delicate.

There are two forms of dissection-wounds,—one in which the local, and the other in which the constitutional, symptoms predominate. *Dissection-wounds which have chiefly a local significance* consist in a scratch, puncture, or abrasion produced by a knife, needle, or spiculum of bone, which, two or three days after the accident, is followed by a red, angry point, usually on some part of the hand, accompanied by intense itching or smarting, which sensation may be the first symptom to apprise the patient of what has happened. This red point is soon surmounted by a minute vesicle, filled with serum, which opens and discharges, forming an ulcer, from which flows a sero-purulent matter, often tinged with blood. In many instances the disease is arrested at this stage; the minute ulcer becoming surrounded by a wall of lymph, the dead particles of tissue separating, granulations springing up, and cicatrization gradually taking place, leaving for some time a livid discoloration.

In other cases the resulting ulcer is surrounded for a short time with an erythematous blush; its boundaries enlarge, the edges become indurated, elevated, irregular, and everted; the soft parts for some distance around are swollen, and assume a brawny appearance; the bottom of the ulcer becomes covered with a gray pultaceous layer of necrosed connective tissue; the few granulations present are pale and unhealthy, and the pain is very severe, having a burning and throbbing character; the patient's appetite fails, he

passes sleepless nights, and may have a slight rigor, followed by febrile disturbance of the circulation.

The ulcer may remain in this condition, in defiance of all treatment, for two or three weeks, before the slough separates and repair commences. The sketch below (Fig. 147), taken from the hand of a prominent professional friend, furnishes an excellent representation of the dissecting ulcer described.

FIG. 147.

Ulcer the result of a dissecting-wound.

In other cases, from the centre of local mischief one or more red lines extend up the arm along the course of the lymphatics. At the same time there may be a slight rigor, followed by an elevation of the temperature, a frequent pulse, and headache. At this stage the lymph in the absorbent vessels, under the influence of the poison, may undergo coagulation, and the further progress of the disease be arrested. Should this not occur, and the lymphangitis continue to extend, the glands, as the supra-condyloid and axillary, into which the lymph-vessels empty, will receive the infectious matter and become inflamed, tender, and swollen. Here again the enemy may be arrested, and its further passage effectually disputed, by the inflammatory transudation into the gland-structure, which so modifies the virus as to prevent its passage into the emergent lymphatics, in consequence of which the constitutional infection is escaped. Not unfrequently the glandular inflammation, excited by the presence of the virus, runs on to suppuration, and this may also disarm the poison of all specific properties and abort the disease. It is possible that many of the phenomena described may be caused by the operation of putrid matters alone, independent of any specific poison.

Dissecting-wounds with marked constitutional involvement.—In this form of the disease the constitutional symptoms to be described may arise twenty-four hours after inoculation, and before there are any local manifestations of the injury. This was so in the case of Professor Dease, of Dublin, who died on the eighth day after the attack. It is altogether probable that in such a case the poison passes directly into a vein and at once induces changes in the blood. Generally, however, in the form of the disease under consideration, a preliminary lymphangitis and glandular enlargement are present. In addition to these the entire arm becomes swollen, œdematous, and of a dusky-red color. The swelling frequently extends to the neck, shoulder, and down the side of the trunk. There is evidently present in such cases a diffuse cellulitis similar to that seen in erysipelas, which is attended with the same disposition to the formation of diffuse abscess.

The constitutional disturbance which accompanies this grave condition reveals more than the local operation of the poison. It indicates that the latter has entered the circulation, and, acting as a ferment in the blood, has given rise to the phenomenon of septicæmia or pyæmia. There are alternations of rigors with flushes of heat; a high temperature, and a feeble, frequent pulse; a dry, furred tongue, which soon becomes brown; a sallow or icterode condition of the skin, with emaciation, delirium, and extreme weakness, followed by profuse sweats, diarrhœa, pleuritic stitches, and cough. Notwithstanding the presence of so formidable an array of symptoms, the patient may struggle through and recover, even out of the very jaws of death. As a rule, however, such cases prove fatal, only one out of seven, according to Travers, recovering.

The disease, when it exists in this form, is capable of being communicated; and the surgeon who has charge of such a case should be exceedingly discreet in dressing the wounds of others. If there be present a latent disease of the kidney in a person suffering from the constitutional effects of a dissecting-wound, it will be developed into fatal activity by the poison. It was in consequence of such a complication that two very promising young physicians died in Philadelphia,—one becoming inoculated whilst making an autopsy in the Pennsylvania Hospital, and the other after receiving a slight scratch while exploring a foul slough on the leg of an unhealthy child.

Treatment.—Professional men who are much engaged in making post-mortem examinations, students of medicine, demonstrators of anatomy, and those pursuing the study of pathology, should thoroughly anoint their hands with sweet oil before exposing them to putrid or other matters of the cadaver. Should a finger receive a cut, scratch, or puncture, the bleeding should be encouraged by squeezing the part above the wound between the thumb and finger. The wound should be washed under a stream of water, and, if there be no chaps or abrasions on the lips or tongue, be vigorously sucked, after which it may be immersed in a solution of the chloride of zinc. I am quite confident that this latter agent will, if promptly used, destroy everything of a specific nature about the wound and render it entirely harmless. I have always opposed the practice, so prevalent at one time, of applying to dissecting-wounds the nitrate of silver. It has no penetrating power, like that of zinc: it only forms a film, and seals up the poison within. When the vesicle or pustule has already formed, with the usual itching and surrounding redness, it should be opened and covered with a hot flaxseed-meal poultice moistened with laudanum. This proves very soothing and favors suppuration. If the ulcer be very painful, the application of a solution of chloral, or penciling its surface with iodoform, will give great relief. The hand should be placed on a splint, or in a sling, to secure quiet; the bowels opened by a mercurial cathartic, such as the compound cathartic pill; the diet—partly solid and partly liquid—regulated so that it shall be nutritious and at the same time unirritating. If red lines have begun to stretch up the arm, it should be encircled by a blister above the disease, which, if timely applied, will stay the further progress of the inflammation. Professor E. Wallace speaks highly of the use of strong mercurial ointment applied over the entire arm in such cases. Extreme tension of the member, indicating cellular infiltration, must be met by free incisions, as in phlegmonous erysipelas. If abscesses form in the cellular or glandular structures, they must be opened early, and the whole arm enveloped in a lotion of hot water, containing a little laudanum, and covered in with oiled silk, waxed paper, or rubber tissue. In the severer form of the disease,—that in which the constitution is invaded,—the treatment does not differ from that proper in a case of typhoid fever. The great object will be to sustain the powers of life until the poison is eliminated, which may involve a struggle of many weeks. To this end there should be given tonics, as quinine and iron, opium in some form to relieve pain and procure sleep, stimulants, such as brandy or whisky, and a diet in which milk and animal broths have a conspicuous place. A patient who

has gone through such an ordeal safely, with perhaps a wasted and deformed finger, will be a long time in recovering strength; will require a change of air, and perhaps the use of cod-liver oil and other alteratives. Many never regain altogether their original health, being harassed from time to time with boils and carbuncles, or affected, on slight changes of the weather, with soreness of the joints.

Anatomical Tubercle.—Persons who are in the habit of making autopsies, or of discharging the duties of demonstrators in anatomical-rooms, their hands being constantly exposed to the fluids of the cadaver, are occasionally affected with a rugose or wart-like thickening of the skin over the knuckles, to which the name *Verruca microgenica* has been given (Fig. 148) by Dr. Wilks. It is not necessary for the production of the disease that there should be any break or scratch in the skin, the simple irritation of its surface serving to produce the epithelial thickening and hypertrophy of the cutaneous papillæ beneath. The disease is certainly very rarely met with in America, as I can recall but a single example of the kind. Its treatment consists in the application of dilute nitric acid.

FIG. 148.

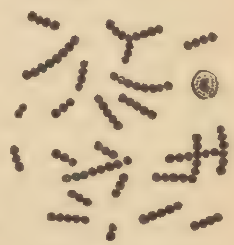
Anatomical tubercle of the fingers.—From Bryant.

Malignant Pustule.

This is a disease of a most serious character, derived, it is believed, from the bodies of cattle which have been the subjects of a peculiar affection known as *murrain*, which is of very ancient origin, and was one of the plagues sent by God upon the cattle of Pharaoh, as we learn by reference to Exodus ix. 3. Among the Greeks and Romans the disease was called *anthrax*, *sacer ignis*, and *carbunculus*. The Arabians knew it as the *Persian fire*, and the French as *charbon*, when occurring in man. It affects horned cattle, sheep, horses, and asses. Though the disease has prevailed chiefly in France, Germany, Switzerland, and other countries of the continent of Europe, it is not unfamiliar in many parts of the United States, especially the cattle-raising districts of the West and Southwest, as Ohio, Illinois, Tennessee, and Louisiana. It is infectious, and may prevail either in an epidemic or in a sporadic form. When it attacks a herd of cattle the fatality is sometimes very great.

CAUSES.—The nature of the disease is very obscure. Heusinger* believes it to be malarial in its origin, operating through certain nervous ganglia upon portions of the blood-vessel system, producing stasis, transudation, and extravasation, and forming in these foci of local disturbance some peculiar septic material, which being taken up by the lymph or blood, and acting as a ferment, is thus disseminated through the body. Virchow† entertains very much the same view. Pollender‡ discovered in the blood of diseased animals certain vegetable organisms or rod-like bodies which in his judgment constitute the contagious principle. (Fig. 149.) These bodies are considered by another writer—Davaine§—as *bacteridiæ*, so extremely small that he calculated eight or ten millions might exist in a single drop of affected blood. Others—among them Brauell and

FIG. 149.



Anthrax bacteria.

* Die Milzbrandkrankheiten der Thiere und des Menschen, Histor.-geog.-pathol. Untersuchungen, Erlangen, 1850.

† Virchow's Archiv, 1857, xi. 132.

‡ Mikroskop. und mikrochem. Untersuchungen des Milzbrandblutes, etc., Casper's Vierteljahrschrift f. ger. u. öff. Medicin, 1855, viii. 103.

§ Comptes-Rendus de l'Académie des Sciences, 1863, t. lvii. p. 220.

Sanson—believe that the disease arises from geological conditions of soil. It is thought by some writers that the carcasses of affected animals buried in the earth impart certain materials to the ground which render it highly poisonous. Some regions in Switzerland are called anthrax, from the fact that the numerous bodies of diseased cattle remaining unburied have rendered the air poisonous and capable of infecting those who come within its influence. The effect of *murrain* on the animal is to render every part of the body poisonous,—blood, flesh, hides, hair, hoofs, horns, and excrement. It is alleged that dogs, after feeding on such carcasses, die. I have witnessed, however, these animals eating freely of the flesh of cattle which have died of murrain, without any evil effects; and it is known that the buzzard consumes such carrion with like impunity.

Anthrax in man.—The disease never arises in man except as the result of a poison derived from infected animals. It enters the system by inoculation in different ways. Tanners and butchers become affected through an abrasion of the skin, or perhaps without such lesion, through the hair-follicles. Fournier* speaks of persons engaged in the tapestry-factories of Montpellier contracting the disease from the wool; and Kolb† mentions the fact of persons becoming affected from rags in a paper-factory in Styria. Broca asserts that workers in leather are often the subjects of the poison;‡ and Dr. Stone, of Massachusetts, reported a number of cases which were traced to handling and preparing curled hair.

Though it is true that animals which feed on the bodies of diseased cattle escape the disease, yet they become media for communicating it to others. Professor Gross mentions the history of three persons who were attacked by the disease after picking the feathers and removing the viscera of a buzzard. The proboscis of an insect like the fly may become the bearer of the poison. The harness worn by infected animals, the grain growing from a soil in which the bodies of diseased cattle have been buried, the soil itself, are all said to be capable of communicating the disease, so wonderfully do they retain the poison. Even alcohol seems to have no destructive power over the poisonous material. In the summer of 1875 I was called to a neighboring town to see a case of obscure disease, which proved to be malignant pustule. The patient was in a dying condition when I reached him. During his illness a handkerchief was frequently moistened from a bottle containing alcohol, and applied to the face of the patient. Six months after, the wife of this gentleman, having occasion to apply some alcohol to her face, without thinking of its former use, took the same bottle from a closet and used it for that purpose. In a short time a pimple made its appearance, which rapidly assumed all the characteristics of malignant pustule; and her life was saved only by free incisions into the diseased part.

SYMPTOMS.—In a variable period, from a few hours to twelve or fourteen days, a person who may have been engaged in skinning, washing the wool, or handling the viscera or even the hides of infected animals, discovers a small red point on the hand, the itching or burning sensation of which is very similar to that which is experienced in serious dissection-wounds. This pimple in a short time is converted into a papule, surmounted by a reddish or bluish vesicle. The rupture of this vesicle occurs spontaneously, or by violent scratching, and leaves a dry and livid excoriation, around which an inflammatory swelling takes place, and at the outer margin of which secondary vesicles, like satellites, make their appearance. From this focus of local poisoning other changes follow. An inflammatory thickening extends far beyond the limits of the inoculated point, with transudation of serum, rendering the parts œdematous and painful. This swelling may spread over the entire arm, face, or head, according to the position of the pimple. Red streaks or lines frequently follow the course of the absorbents, ultimately in-

* Observations et Expériences sur les Charbons malins, Dijon, 1757 and 1769.
† Wiener Med. Presse, Nos. 7 and 8, 1870.
‡ Bull. de l'Acad. de Méd., 1868, xxxiii. 367.

volving the glands in direct communication with these vessels. Should the infiltration be great, gangrene may invade the cellular tissue. In the course of forty-eight hours, or longer, constitutional symptoms set in. The skin becomes hot, though previously it may have been cool; the pulse quickens; pains like those of rheumatism are experienced in the limbs and articulations; the strength rapidly fails, the mind wanders, the thirst increases; the tongue becomes dry and covered with a scanty dark coat; the bowels are disturbed; profuse cold sweats follow, with difficulty of respiration, and prostration. Should not the eschar become detached by suppuration and the disease take a favorable turn, death will ensue in five or six days.

There is another form of the disease, which is supposed by Guipon to be due to poison introduced into the system either through the influence of infected air entering by the air-passages or eaten in the flesh of diseased animals. The late observations of Wagner and others establish this as an intestinal variety of the affection. In this form the external manifestations are secondary: when they appear, there is usually swelling of the eyelids, face, or other parts of the body, the intumescence having a yellowish hue. I am quite certain that I once witnessed a fatal instance of this disease,—how contracted I am unable to say,—which might, but for this color, have been mistaken for erysipelas. This case was attended with great difficulty of breathing and a feeble action of the heart.

In cases which are regarded as having an intestinal origin,—that is, from diseased flesh taken into the stomach,—the constitutional symptoms will often make their appearance in a few hours, or they may be delayed one or two days. When the invasion does take place, the patient is usually seized with a rigor, nausea, vomiting, abdominal pains, and great debility; but it may develop in a more quiet way, like certain febrile diseases, with chilliness, restlessness, a general sense of indisposition, headache, loss of appetite, and increasing prostration. After eight or ten days carbuncles make their appearance on the surface, followed by œdema and gangrene of the cellular tissue, with labored respiration, lividity of the face, collapse, stupor, and death.

Pathology.—In that form of the disease which is the result of inoculation through the skin, if incisions be made into the integument the cellular tissue will be found loaded with serum and lymph, and in those portions corresponding to the anthrax it will be in a state of necrosis, filled with an infiltration of serum, lymph, and blood, extending into the surrounding cellulo-adipose structure. In the submucous tissue of the mouth, fauces, and larynx spots of ecchymosis are seen, due to the dissolved condition of the blood. The cervical and intra-thoracic lymphatic glands participate in the disease, being infiltrated with serum and blood very similarly to the subcutaneous tissue. Underneath the serous membrane of the chest, as well as in the cavity of the pleura, there are transudations of serum. The blood in the heart and principal trunks is dark red, and remains in a fluid condition. In the intestinal variety, the walls of the stomach and alimentary canal lose their shining or glistening appearance, being infiltrated with stained serum. In the cavity of the peritoneum exists a transudation similar to that in the pleural cavity, perhaps containing a larger amount of changed blood. The same blood-stained fluid is met with in the mesentery, with infiltration of its glands. Hemorrhagic infarctions, along with serum, exist in the submucous tissue of the intestines, giving rise to a swollen œdematous condition. Upon the mucous surfaces, as on the skin, are found true carbuncles, which, made up of bloody serum and necrosed submucous tissue, and having a grayish-yellow color, project in a papular form from the mucous surface of the intestine. Both underneath the capsule of the kidneys and the mucous membrane lining the infundibulum and pelvis are serous and bloody extravasations. The same is true of the liver, brain, and its membranes. It will appear from this enumeration that the dominant pathological features consist in the transudation of serum and blood, both in the subserous and submucous tissues as well as into the cavities of the one and upon the surfaces of the other.

The microscopical appearances of the carbuncles are very significant. Disseminated through the diseased tissue, as well as in its cells, are seen crowds of bacteria, both round and rod-like. According to Davaine,* by the third day these simple organisms form a large constituent of the carbuncular mass, from which they penetrate into the blood-vessels and are thus widely disseminated throughout the system. These bacteria are found also in all the submucous, subserous, glandular, and other infiltrations belonging to the disease.

Prognosis.—Much depends on an early recognition of, and a prompt attention to, the disease. The subcutaneous form is less serious than the intestinal; it is more readily diagnosed, and therefore can be attacked immediately on its appearance. Lengyel and Korányi lost only thirteen out of one hundred and forty-two cases, and Nicolai† but eleven out of two hundred and nine. The two patients who have been under my own care recovered. In intestinal anthrax a favorable result is very rare.

Treatment.—The treatment resolves itself into the preventive and the curative. To accomplish the first, the strong arm of legislative sanction is required, enforced in the most rigorous manner, making imperative the inspection of all animals, and disallowing the use of any part of diseased cattle, either for food or mercantile purposes. A further protection would be extended by employing in tanneries and wool and hair manufactories such an agent as carbolic acid, which it is believed destroys the specific property of the poison and renders the materials employed innocuous. The curative treatment consists either in excision of the carbuncle in its entirety, or in free incisions into and beyond its limits, followed by thorough cauterization with caustic potash, nitric acid, bromine, or carbolic acid. In one of my own cases the anthrax was isolated from the surrounding parts by two elliptical incisions, and then divided in a crucial manner before cauterization; in the other it was excised: in each a favorable result followed. When incision is practiced, the wounds should be afterwards filled with lint soaked in carbolic acid, and covered with a light poultice of flaxseed-meal overspread with brewers' yeast or basilicon ointment, to facilitate the separation of the slough.

When the disease has passed beyond the local infection, and involves the general system, or when it appears in the intestinal form, our hopes must rest on the use of such agents as are supposed to exert a salutary or specific influence upon septic matters, and the proper nutrition of the system. For the first, carbolic acid should be liberally administered internally, with quinine and a generous diet, together with wine or brandy. Anodynes should be given to alleviate pain and restlessness when present; and when there is much œdema and infiltration, free incisions are allowable, to limit the strangulation of tissue, enveloping the parts subsequently with lotions of warm chamomile-tea or carbolated water.

Foot and Mouth Disease.

The foot and mouth disease is met with among cattle, swine, sheep, and goats, and is characterized by both local and constitutional symptoms. The local manifestations consist of vesicles and ulcers on the mucous membrane of the mouth, at the top and in the cleft of the hoof; also, in the form of pustules, on the udder and teats of cows. The constitutional disturbance is manifested by well-marked febrile excitement. This disease is infectious, and capable of being communicated from one animal to another, both by contact and through the medium of the atmosphere. The virus, in whatever it may consist, is transportable by clothing, harness, and other materials. It is contained not only in the vesicles and ulcers, but also in all the secretions and excretions of the affected animal.

This affection may be communicated to man either through the unboiled

* Ziemssen's Cyclopædia of the Practice of Medicine, 1875, vol. iii. p. 425.
† Ibid., vol. iii. p. 426.

milk or by inoculation,—a discovery made by Hertwig, who, with other medical men, induced the disease in his own person by drinking the milk taken from cows laboring under the affection. It is from this cause that so large a number of the calves of cows affected with the disease die, the milk producing inflammation of the stomach and intestines.

Symptoms of the Disease in Man.—Like many other animal poisons, it has a period of latency or incubation, and one of activity; the former lasts from three to five days, the latter is initiated by febrile disturbance, often preceded by a rigor. There are also headache, a dry mouth, and loss of appetite. These symptoms are followed, after a few days, by vesicles on the lips, tongue, palate, and pharynx. These contain a faint-yellow and turbid fluid, and after rupture leave ulcerations. The inflammatory state of the mucous membrane excites a profuse salivation, with difficulty in deglutition. These vesicles are not confined to the mouth and pharynx, but may appear upon the hands, sometimes on the feet, and with a tendency to attack the matrix of the nails. The occurrence of diarrhœa with abdominal pains indicates inflammatory disturbance of the stomach and intestines. The disease usually runs its course in ten days or two weeks, and terminates in recovery. Children suffer most.

Treatment.—A careful scrutiny of the milk should be made, in order to secure a pure supply; the mouth must be frequently cleansed with a wash of chlorate of potash sweetened with honey, or one of salicylic acid, or of borax. The points of ulceration should be touched with a crayon of nitrate of silver, and the diarrhœa and pain corrected, when present, with chalk mixture and the camphorated tincture of opium.

Glanders, or Farcy.

Glanders and farcy are not two distinct affections, as might be supposed from the manner in which they are sometimes treated in surgical works. Farcy is a result of glanders, being only the cutaneous manifestation of the latter. It is a contagious and infectious disease appearing in the horse, and from this animal, under favoring circumstances, communicated to man. The disease, it is alleged, can be communicated to all domestic animals except horned cattle. It has prevailed extensively in France, Hungary, and other countries of Europe: in Hungary twenty thousand horses are said to have died of the disease in eight years. There is no evidence that the disease ever arises spontaneously among horses. It is certainly not necessary that there shall be any abrasion or crack in the continuity of the skin or mucous membrane for one animal to communicate it to another. The virus is of so subtle a nature that it is probably absorbed through the air-passages, or perhaps taken into the system with the food. The discharges from an infected animal have been placed for some time in contact with the nasal mucous membrane of a sound horse without communicating the disease. I have seen a glandered horse stabled for a period of weeks with others which were sound without any of the animals becoming affected. Lamirault,* as stated by Bollinger, placed one hundred and thirty-eight healthy horses among others which were glandered; they were fed and worked together, and yet only twenty-nine of the former suffered from the disease. These examples show that there must be certain favoring constitutional conditions for its communication. The disease, as it appears in animals, has a period of incubation which varies in duration from four or five days to several weeks, according as it is produced by direct inoculation or by the contiguity of an infected horse. As it develops, an inflammatory action localizes itself in the mucous membrane of the larynx and air-passages, as well as in the upper part of the nasal cavities, sometimes giving rise to cough and fever, with a discharge from the nose, consisting of a thin and watery, at other times of a yellow or purulent, matter. The inflammatory change in the Schneiderian membrane of the nasal cavities and the resulting ulceration are followed by a

* Hering, Canstatt's Jahresbericht f. d. J. 1849, p. 35.

discharge, which becomes sanious, offensive, and irritating to the parts over which it flows, and which accumulates in brown or yellowish crusts about the anterior nares. The glands under the jaw become enlarged, and in the subcutaneous tissue of the legs, head, neck, abdomen, and other portions of the body, indurations form, some of which remain as hard knots, while others break down into ulcers with ragged edges; these constitute what are commonly known as "*farcy buds*" and "*farcy sores*." At the same time, emaciation progresses, the coat of the animal becomes rough and stare, the strength wastes, and death follows from exhaustion, pyæmia, and sometimes from pneumonia. The infecting material of glanders exists in all the nodules, ulcers, and discharges induced by the disease.

Glanders in man.—The earliest observations on the communicability of glanders to man were made by a French military surgeon, Lorin,* since whose time valuable papers on the subject have been contributed by numerous German, English, and French writers, among whom may be mentioned Travers, Elliotson, Rayer, Virchow, and Korányi. Glanders is communicated through a crack or abrasion on the hands; by the nasal discharges being blown violently from the nostrils of the horse into the eye or a sore upon the face; or it may follow the bite of the diseased animal. It is often communicated by the filthy and reckless practice of grooms or stable-men wiping their faces with the sponge used in washing the mouths and nostrils of horses. It may be contracted also by grooming, by post-mortem examinations of diseased horses, or even by inhaling the volatile emanations or poison whilst sleeping in a stall near a glandered animal. Eating the meat of a diseased horse—which under pressing circumstances is sometimes done—may communicate the affection. It is in this way, according to Bollinger, that the disease among lions in menageries arises. From man it can be communicated back to animals, and there are not wanting cases showing that one man may communicate it to another. Of one hundred and six cases collected by Bollinger, forty-one occurred in hostlers; eleven in coachmen; fourteen in farmers, owners of horses; ten in veterinary surgeons; and twelve in horse-butchers and flayers; the remaining eighteen being distributed among seven other industries; showing that those occupations which bring persons most in contact with horses are those which most predispose to the disease.

SYMPTOMS.—The disease has been divided into the *acute* and the *chronic*, distinctions founded on the rapidity of its course. The latest writer upon the subject, Dr. Bollinger,† makes an intermediate or *subacute* variety. By some it is supposed that the type of the disease is determined by the manner of infection; that when it is contracted by inoculation through a crack or abrasion in the skin, its course will be acute, and when through the inspiration of poisoned air, it will be chronic. By whatever mode this virus is introduced into the system, there will be a period of incubation lasting from three to sixteen days.

The symptoms which usher in the acute disease are not unlike those which foreshadow an attack of typhoid fever or rheumatism, such as muscular soreness, indisposition to exertion, headache, loss of appetite, general malaise, with articular pains, and decided physical weakness, with or without fever. Should there be no external lesion, red spots make their appearance in the skin, not unlike the early stage of variola, some of which develop into pustules, while others remain for some time as circumscribed indurations, varying from the size of a buckshot to that of a pea. These may become so numerous as to cover the entire body. Some of these indurations open and discharge a sero-sanguinolent fluid, leaving deep, unhealthy ulcers, which extend through all the subjacent structures. When there has been a scratch or crack, through which the poison or virus has entered, the earliest local manifestation will be redness, pain, and swelling, commencing at the point of inoculation and

* Observations sur la Communication du Farcin des Chevaux aux Hommes. Jour. de Méd. Chirurg. et Pharm., Février, 1812.

† Ziemssen's Cyclopædia of the Practice of Medicine, vol. iii.

extending up the arm, if it be this part which has been injured, and, like erysipelas, having a dusky-red color. Radiating streaks in the line of the lymphatics are also frequently present. The crack or abrasion breaks down into an ulcer, with indurated and irregular edges, and which discharges unhealthy and irritating pus. While these changes are taking place in the skin and subcutaneous structures, the mucous membrane of the nose becomes involved, although, it is said, less frequently in men than in horses. At first the discharge from the cavity is a thin, tenacious mucus, exuding from the general surface, as the result of a diffuse inflammation. In a short time the secretion becomes more purulent or catarrhal, and finally bloody, with an offensive odor. As in the skin, so also in the submucous tissue, indurations form, which follow a course similar to the first, bursting or ulcerating, and forming deep-seated erosions, which may, when situated beneath the Schneiderian membrane, finally attack the cartilages of the nose. This nasal condition is attended with a diffused or erysipelatous redness and pain of the entire organ. These inflammatory changes are not confined to the nasal mucous membrane. They seem to spread from the nose by structural contiguity to the palate, pharynx, larynx, trachea, and bronchia, producing hoarseness, alteration of voice, cough, and expectoration of a character corresponding to that of the discharge from the nose. This inflammation appears also in the fauces and mouth, and travels along the ductus ad nasum to the conjunctiva, extending likewise to the intestinal mucous membrane, and exciting diarrhœa. The tongue is coated with a dark crust, the thirst becomes urgent, and the circulation is accelerated though weak, with a temperature of six or seven degrees above the normal standard. The submaxillary and sublingual glands also enlarge and suppurate, and as the disease advances the weakness becomes greater; emaciation progresses, the mind wanders, and the patient finally sinks, in four or five weeks, into a state of insensibility, from which he never recovers. It is doubtful if any cases of acute glanders terminate otherwise than fatally.

In the chronic variety of glanders the progress of the disease is more tardy, though the lesions are essentially the same as in the acute. There is also in the former a greater recuperative power displayed, many of the ulcers healing and leaving a layer of cicatricial tissue, which, when it is situated in the mucous canals, may, from its tendency to contraction, produce such a narrowing and deformity of the nasal fossæ as will interfere very materially with the proper execution of their functions. The duration of chronic glanders is about four months; and it is this variety which is the least fatal. As many as fifty per cent., it is said, recover more or less perfectly.

Pathology.—The chief pathological features are the widely-disseminated abscesses through the cellular tissue, also the presence of papules, pustules, and nodules in the submucous and subserous structures, together with enlargement and suppuration of the salivary glands, doughy thickening about and purulent effusion within the articulations. Few organs escape its ravages. In the spleen, liver, lungs, brain, and testes, are found inflammatory infiltrations and abscesses. The indurations, when examined microscopically, exhibit little else than an enormous aggregation of dead leucocytes or pus-cells.

Treatment.—Unfortunately, there are no remedies which exercise any specific influence over the disease when it is once established. The great indication is to sustain life in the fearful struggle, with the faint hope that the morbid products may be ultimately eliminated. To this end may be administered quinine, alcohol, milk, and nutritious broths. The internal use of carbolic acid, from its antiseptic properties, is worthy of further trial. When a local sore has been poisoned by the virus, the part should be excised, or destroyed by powerful caustics, like the caustic potash or bromine, and all indurations, whether suppurating or not, should be freely incised and treated with carbolic acid and olive oil (one part of the acid to nine parts of oil).

Equinia mitis.—Persons who handle the feet of horses suffering from what

is called grease—a viscid, offensive discharge from the fissure between the quarters of the heel—have frequently an eruption of superficial pustules from the irritating property of the discharge. It is quite a common affection among hostlers and veterinary surgeons, and proves entirely harmless. The treatment is very simple, and consists in washing the parts clean and touching the diseased points with a weak solution of the sulphate of copper (four grains to the fluidounce of water).

Hydrophobia.

This dreadful malady, the most terrible disease that can befall a human being, was not unknown to the ancient physicians; and there are frequent allusions to it in the classical writings of the Greeks and Romans.

Though it is alleged that the disease may arise spontaneously in animals of the canine species, yet the statement rests on a very improbable foundation.

Among the supposed causes may be enumerated the following:

1. *Extreme heat.*—The disease, however, is not peculiar to any climate. It is met with at the equator and in the frozen regions of the North. In 1863 it prevailed to such an extent in Northern Greenland* as to destroy all the dogs in certain localities.

2. *Certain seasons of the year.*—There is no evidence that the disease is in any way influenced by particular periods of the year. Of the three hundred and two cases given by Bouley, eighty-nine were in the spring, seventy-four in the summer, sixty-four in the autumn, and seventy-five during the winter months.

3. *Starvation and thirst.*—There are no facts to render it probable that the want either of food or of water can originate the disease. Dogs have frequently died from starvation on shipboard, where supplies were short or exhausted, yet without manifesting any signs of hydrophobia. Dupuytren, Magendie, Radi, and others have starved dogs to determine this point, but in no instance has rabies been induced; and Pillwax noticed that when the disease was quite prevalent in Vienna the dogs which suffered most were those belonging to the wealthy, and therefore likely to be well supplied with food.

4. *Ungratified sexual passion.*—The fact that castrated dogs and spayed bitches enjoy no immunity from the disease is a sufficient refutation of the theory of this being a cause.

5. *Anger or rage.*—It has been often asserted that the bite of an irritated or enraged dog is sufficient to produce rabies; yet every one has witnessed instances of such bites without any evil effects whatever, save an indolent wound, the inactivity of which is to be referred more to the contused character of the injury than to any other cause.

Janeway† alleges that the mephitic virus of the skunk will give rise to hydrophobia. I have known many conflicts between the dog and this animal, the only effect being to render the former for a time offensive from the presence of an unpleasant odor.

It is the opinion of the very best authorities, such as Youatt, Schraeder, Virchow, and others, that the disease can arise, either in the dog or in man, only by the introduction of a specific poison or virus through an abrasion of structure, and that a poison also which is not communicable, like malignant pustule, through intermediate agencies, such as flies or fleas, or through the consumption of flesh or milk. The disease in its origin is not peculiar to dogs, but is frequently communicated to them from the fox. It is stated by Oertl, as recorded by Bollinger, that hydrophobia prevailed as an epizootic among the foxes of Carinthia from 1866 to 1872, and that many dogs, as well as other animals, were bitten by them.

The peculiar infecting material or virus is contained in the salivary and

* Leisering, Jahresbericht über Thierheilkunde, 1866, p. 448.
† New York Medical Record, March 13, 1875.

other secretions of the mouth; possibly also in the blood. It is necessary that there shall be an abrasion for its reception into the system. Upon the unbroken surface of either skin or mucous membrane the virus is harmless. Hertwig* gave to animals the milk and flesh of others suffering from or dying of hydrophobia, without any positive results; the saliva and blood were also administered internally, with no injurious effect. The same writer placed sound animals in the stalls and kennels of rabid ones, tied them with the same halters, allowed them to lie on the same bedding, and in no instance with the effect of inducing the disease. Of the number of animals bitten, a very small proportion go mad. Of one hundred and thirty-seven bitten from 1823 to 1827, and kept under observation by the Veterinary School at Berlin, only six died from hydrophobia. In Würtemberg, from 1864 to 1867, out of nine hundred and forty-three animals thus injured, only twenty-eight were attacked with rabies.† Youatt, however, one of the very best authorities, believes that two-thirds of bitten animals go mad; and Trousseau places the number at about one-half. This infrequency is perhaps not due to any constitutional indisposition to or want of susceptibility on the part of the animal receiving the poison, but to causes calculated to wipe off or cleanse the virus from the teeth before the wound is inflicted.

Symptoms.—Among animals there is a want of uniformity in the phenomena of the disease. There is a stage of *incubation*, which, though subject to great variations as to time, is usually from four to six weeks; and there is reason to believe that even during this period the bite of the animal may produce the disease. Even after the invasion of hydrophobia, the order and manifestation of the symptoms are such as to warrant the division, made by Youatt, into the *furious* or *violent* and the *sullen* variety; though others, and among them Virchow, think that these are only different stages of the disease. That the division is just I am convinced, having witnessed typical cases of each.

The furious form.—In this variety there is a premonitory or inaugurating stage, which may last from twenty-four hours to three or four days. During this time the behavior of the animal is changed. The dog appears unhappy, discontented, restless; frequently changes his position or place; avoids observation, and does not court caresses; and is easily irritated and provoked to snap or bite from causes which ordinarily would not disturb his temper. The conjunctiva becomes injected, which, with the corrugated brow, imparts a sullen appearance to the animal. He is given to licking objects or substances at hand, such as the carpet, floor, or cold stones; the appetite is lost or perverted, so that substances are devoured which usually would be avoided, as old rags, straw, or his own fæces. Emaciation takes place rapidly, and the animal becomes subject to hallucinations, jumping or snapping at imaginary objects. There may be sexual excitement. The gait becomes unsteady and staggering, and substances are dropped from the mouth, or are swallowed with difficulty. It is not always the case that the disease approaches after the manner described. It often breaks forth, without premonition, into the violent state. The dog escapes from his kennel, and roams aimlessly over the country, traversing fabulous distances in a short time; he snaps or bites at anything in his way, gnaws his own feet or tail, and is equally indifferent to strangers and to friends. The voice is altered, becoming hoarse and husky; the eyes glare with fury. Water, contrary to the popular notion, is not avoided, but is drunk with avidity, except in cases where there is muscular spasm of the pharyngeal muscles. Sometimes the saliva flows from the mouth mixed with foam; at other times there is a total absence of the secretion. This stage is characterized by an intermission, during which the animal may return to his home, and his demeanor become so changed as to remove all suspicion of disease. In a short time, however, another paroxysm sets in, and in three or four days from the attack the final stage—that of *paralysis*—

* Die Krankheiten der Hunde und deren Heilung, Berlin, 1853.

† Ziemssen's Cyclopædia of the Practice of Medicine, vol. iii. p. 442.

is reached, during which the emaciation greatly increases, the flanks fall in, the hair becomes rough and stare, the eyes are sunken and shining, the lower jaw falls, and the tongue protrudes, all of which, together with the air of extreme dejection, gives a horrid appearance to the animal. The paralysis affects most the hinder extremities: he staggers, falls, rises on his fore legs when unable to stand on all four, and will snap and bite in this position. The breathing, which before was hurried, now becomes labored, and he passes into a state of coma, or dies in a violent convulsion after the lapse of from five to seven days from the commencement of the attack.

The sullen variety.—In this form of rabies the animal is quiet, shy, loses appetite, is not very irritable, shows no great disposition either to bite or to wander away, and loses flesh rapidly. Deglutition becomes difficult; the food is dropped from the mouth in the attempt to swallow; the lower jaw falls; there is frothing at the mouth, with dribbling of mucus and saliva; the voice is lost, and paralysis, not only of the jaw, but also of the hinder limbs, occurs; the body is seized with tremors, and in two or three days the animal dies. It is said that in this variety of the disease the dog shows no disposition to lick; but in one of my own dogs which died of rabies, and from whose case this description has been taken, it was a prominent symptom in the early part of the attack.

Hydrophobia in man.—That the disease shall arise in man it is necessary that the virus be introduced through a scratch or wound, usually made by the tooth of a rabid animal, such as a dog, fox, cat, or wolf. There are no facts to warrant the belief that the disease has ever been communicated from man to man; though there is no doubt that the saliva is infectious in its nature and is capable of producing the disease in animals.

Period of incubation.—The period which elapses between the reception of the virus and the explosion of the disease is subject to great variation. The shortest period recorded is three days; and generally it does not extend beyond three or four weeks. There are cases in which the poison has remained latent for over two years; and in a case which occurred in Lancaster County, Pennsylvania, under the care of the late Dr. Wallace, there is every reason for believing that the stage of incubation lasted seventeen years. This period is shorter in the young than in the old. Whatever may be the duration of this stage, there are no sensations which furnish any evidence of the presence of so deadly a poison. The scar or cicatrix presents nothing peculiar; the sensations of anxiety, trepidation, and restlessness, alleged by some to follow when the seat of the injury is touched, are altogether mythical; though at the time when the disease is about to develop the scar may become inflamed and swollen, accompanied with a burning sensation and radiating pains.

It is a very difficult task to determine what proportion of persons bitten suffer from hydrophobia, simply because many dogs that inflict wounds are pronounced mad when such is not the case. There are two circumstances which diminish the probability of infection after the bite of a rabid animal. First, when the wound has been inflicted on the leg or arm, the tooth is likely to be despoiled of its deadly virus in passing through the clothing. It is estimated that not more than twenty per cent. of those bitten on the arm and twenty-eight per cent. of those wounded on the leg die of hydrophobia. Second, where the animal has bitten a number of persons in quick succession, the teeth having been frequently wiped, the individual last injured is least liable to suffer.

The greater the vascularity of the part, the greater is the risk when injured; and this explains why the disease is so much more frequent after bites on the face than after wounds on the hand, the proportion being ninety per cent. in the first and sixty-three per cent. in the last.

Bollinger informs us that the mortality of persons injured by dogs supposed or known to be mad does not exceed eight per cent.: that is, out of thirteen hundred and sixty-two individuals bitten, one hundred and five

die of hydrophobia. The disease would seem to be much more common in France than in England, as over three hundred and nineteen persons died of hydrophobia, between the years 1850 and 1862, in the former country, while in the latter the deaths from this cause during the same period did not exceed ten or twelve a year.

As to its communicability from man to man, I am not aware that there is a single well-attested instance: yet there is no reason why such a result should not follow the bite of a rabid individual. If the saliva of a person so affected can be successfully inoculated into the body of the dog,—as proven by Magendie and Breschet,—why not into the system of human beings?

Males are more frequently the subjects of the disease than females, and children between ten and fifteen years of age suffer oftener than adults or old persons, from the fact that they are more exposed.

Premonitory Symptoms.—The symptoms which usher in the disease are very much akin to those which introduce an ordinary catarrhal or febrile attack. These are, loss of appetite, chilliness, headache, muscular soreness, discomfort about the throat, with great depression of spirits, which finally culminates in peevishness, irritability, restlessness, and a gloomy apprehension of impending evil. The thoughts turn at once to the bite, and to this cause does the doomed patient refer all his distress. The sleep is broken with frightful starts; there will most likely be difficulty both in deglutition and in articulation; great thirst will be present, yet with an uncontrollable aversion to liquids. It is from this last symptom that the disease has taken its name, *hydrophobia;* yet the fear of water is present only when the deglutition is paralyzed. The eyes become injected, and there is a sense of pain or oppression at the præcordia, accompanied with sighing or sobbing. The sexual organs are frequently in a condition of unusual excitation, the patient being annoyed by priapism; and the face, arms, and legs are disturbed by involuntary movements. This stage may last from a few hours to three days. In exceptional instances it has been prolonged to two weeks.

The furious stage.—This stage is characterized by great physical and mental excitement. The fear of water becomes a very prominent symptom, and any attempts to drink provoke the most terrible convulsions: indeed, so great is the exaltation of both the common and the special sensibility of the body that a current of air, a sudden movement on the part of an attendant, the reflection from some lustrous object, or a loud voice, is quite sufficient to produce the most violent spasm of the muscles of the throat, chest, and even of the entire body. In the last case which I witnessed of the disease, there was an almost constant tendency in the head to be drawn backward. In consequence of the convulsive contractions of the muscles of the pharynx and chest, there is a sense of suffocation, and the breathing is carried on in gasps. The distress is intensified by the urgent thirst which is present, any attempts to gratify which fill the patient with fear, and even terror at the very sight of the vessel containing water. The voice is changed, becoming hoarse and husky, from loss of power in the intrinsic muscular apparatus of the larynx; pain at the epigastrium is complained of; the eyes are injected, being either staring or unsteady, and the pupils are dilated; the mouth is filled with froth, which becomes so viscid and tenacious that it is expelled with great difficulty, the patient hawking and forcing it out by short and violent expirations until it is scattered over his clothing and every article about his person. The face has not only an air of deep distress, but also an expression of mingled anxiety and horror, which, together with its purple and livid color during a paroxysm, presents a spectacle the most dreadful that it is possible to behold. During all this time the mind is generally clear, and the unfortunate sufferer, in the intervals between the convulsive attacks, talks incessantly, frequently cautioning his friends to avoid being injured by him, praying that they will not desert him in his distress, or begging that an end be put to his life in order that he may escape from the misery which has become intolerable. This stage usually continues from one to three days.

The stage of paralysis.—This stage is not always recognizable. As the case advances, the pulse becomes frequent and weak, and the paroxysms occur at shorter intervals, until at last, after one of unusual severity, the patient dies, apparently in a state of asphyxia or collapse. The end may approach in a more gradual and quiet manner; the convulsions grow less violent, and finally cease altogether, or are substituted by general muscular twitchings; the respiration becomes easy, though frequent; the power to swallow may return; the eyes are more fixed, or assume the condition of strabismus; the pupils are contracted; the lower jaw drops; the saliva dribbles from the mouth, a perspiration breaks out over the body, and the patient passes away from sheer exhaustion.

The disease rarely extends beyond two or three days. J. L. Smith, of New York, in an analysis of one hundred and twenty cases, found that sixty-five died in from one to two days. Thamhayn, in two hundred and two cases, says that fifty-six died in forty-two hours; seventy-three in forty-eight hours; thirty-eight from the second to the third day; nineteen between the third and fourth days; seven in five days; five in six days; and four in seven days.* Bollinger states that of the whole number dying of hydrophobia, nine per cent. die on the first day, thirty-six per cent. on the second day, and fourteen per cent. on the third day; that is, one-half within three days.

Pathology.—Little light has been thrown upon the subject by post-mortem examinations. The blood-vessels of the brain and spinal marrow, together with their membranes, are found surcharged with blood, with serous effusions depending most probably upon mechanical causes. The same hyperæmia exists in certain nerves and ganglia, as those belonging to the cervical sympathetic and pneumogastric. The mucous membrane of the fauces and pharynx, and their glands, are found deeply injected, and the latter enlarged. This vascular injection may extend to the stomach and intestines. The lungs are engorged with blood and œdematous, with hemorrhagic infarctions. The vesicles described by Marrochetti, of Moscow, and by Xanthos, said to be found under the tongue on each side of the frænum of animals which have been bitten by others, and which are said to contain the poison, have no existence.

Diagnosis.—There are some points of resemblance between hydrophobia, tetanus, and hysteria; but it is not probable that either of the last two will be confounded with this terrible malady.

Hydrophobia may be distinguished from tetanus by the following symptoms. In tetanus there is no horror of fluids, nor excessive sensibility to currents of air. In tetanus the muscular rigidity is continuous; in hydrophobia, while muscular rigidity is present at times, there are intervals of complete relaxation, and finally paralysis comes on, the jaw falling, and the saliva dribbling from the mouth: moreover, in connection with these symptoms there will be the history of an antecedent bite. Again, the wild, injected eye, the furious excitement, and the horrible expression of the face in hydrophobia, altogether unlike the sardonic grin in tetanus, leave little room for doubt as to the true character of the disease.

From hysteria it is distinguished by the fact that in hydrophobia the convulsions arise whether the patient is asleep or awake, and affect the muscles both of respiration and of deglutition. In hydrophobia, also, the reflex sensibility is dominant, whereas in hysterical and other convulsive diseases the reverse is true.

Certain cases of acute mania bear a striking resemblance to rabies; but in the former there is no difficulty in deglutition.

Treatment.—The condition of a person bitten by a rabid dog, while it is one of great peril, is not absolutely hopeless. There is ground for encouragement should the bite have been inflicted through the clothing, as we have learned that in such cases only from twenty to twenty-eight per cent. go mad; and, again, the success which has attended the early treatment by cauterization

* Bryant's Surgery, p. 385.

furnishes an encouraging prospect of escape from the terrors of the disease. Bouley, as quoted by Bollinger, says that of two hundred human beings bitten by rabid animals one hundred and thirty-four were cauterized, of which number ninety-two remained well, or sixty-nine per cent.; whereas in sixty-six cases not cauterized, the death-rate reached eighty-four per cent.* On the reception of a bite by a rabid animal, the wound should be immediately sucked, provided there is no abrasion of the mucous membrane of the lips; or, when feasible, well drawn with a cupping-glass. It should next be washed with carbolic acid and water (one part of the acid to nine parts of the water), and then thoroughly cauterized with caustic potash. Youatt has unbounded confidence in cauterization with nitrate of silver, having tested its efficacy frequently in his own person; but certainly the greater potency of caustic potash would give additional security. It is also advised, after the slough drops out, to keep up suppuration for several weeks by savine or resin ointment, in order to insure the destruction of the virus.

Among the prophylactic means are those sanitary measures which can only be enforced by legislative authority, such as the taxation of dogs, the destruction of all allowed to run at large, and the compulsory use of a muzzle. In Berlin, during the nine years in which dogs were required to be muzzled, not a case of hydrophobia occurred. When it is considered that there are at least twelve millions of dogs in Europe, the only wonder is that the disease is so infrequent.

Where all precautions have proved unavailing, or where none have been employed, and the disease is developed, our duty consists in alleviating as much as possible the sufferings of the patient; for beyond that we are utterly powerless to effect any good. I need not describe the various remedies which have from time to time been employed, such as belladonna, atropia, curare, mercury, large bleedings, quinine, transfusion, carbolic acid, and many others. Nor does opening the trachea, as advised by Physick, promise anything better. Our only resort must be to full doses of morphia hypodermically administered, the inhalation of ether or chloroform, and injections into the rectum of milk and beef-tea, with brandy. A case of rabies in a girl twenty-four years of age is said to have been treated successfully by Offenberg, at Berlin,† by seven hypodermic injections of woorara, the amount used being three grains during a period of five hours and a half.

Poisons derived from Arachnidans and Reptiles.—*Spiders* (*Araneæ*) are said to produce poisonous effects by their bites. On this subject there is a difference of opinion. Any one who tries the experiment will find that it is difficult to provoke these creatures to assume the defensive. Professor Leidy has informed me that their bites are quite harmless. Still, it is difficult to conceive that where a poison-apparatus exists the use of it shall be free from all irritation. The poison-glands of the spider are placed in the abdomen, communicating with the mandibles, at the extremity of which are sharp hooks (Fig. 150), which serve the double purpose of making the puncture and conveying the virus into the wound. The effects of the spider-wounds, as I have seen them, have never been very marked, consisting simply of a red, indurated point, with a moderate degree of itching. Dr. G. W. Semple‡ reports several cases followed by the most alarming local and general symptoms.

Fig. 150.

Poison-apparatus of the spider: *a*, poison-gland; *b*, mandible; *c*, hook.

Some varieties are more poisonous than others. In several of the Southern States there is a small black spider which is very much dreaded by the negroes, and I have been informed by a number of physicians

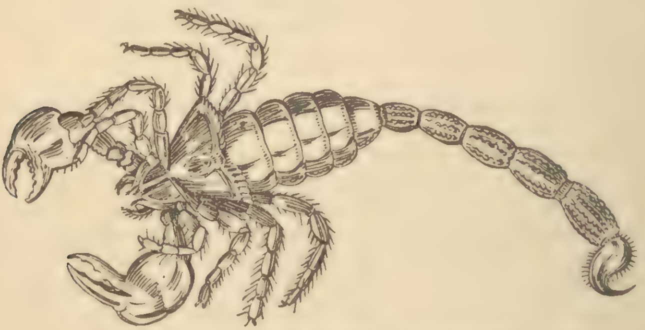
* Bollinger, however, after estimating the results of cauterization, concludes that only thirty-three per cent. of those thus treated fall victims to the disease, whilst eighty-three per cent. of those on whom the operation is not practiced die.

† New York Medical Record, October 21, 1876. ‡ Virginia Medical Monthly, December, 1875.

living in the South that its bite is generally followed by well-marked signs of poisoning. In addition to the pungent pain at the seat of injury, there is nausea, with severe griping pains in the abdomen, followed by a sense of sinking, præcordial distress, difficult breathing, numbness, and in some cases paralysis of the arms. If the disease be not checked, the pulse becomes frequent and feeble, the surface is cold, and there is great anxiety and extreme prostration.

The scorpion is very common in hot climates. It is found in this country chiefly in certain parts of Texas. At the extremity of the prolonged tail is a curved hook or sting, connected with which are two poison-glands (Fig. 151). The poison is destructive to many animals, such as birds and frogs, death following the sting in a few seconds, according to Heinzel. In the experiments of Guyot,* even animals as large as the dog and the guinea-pig perished in fifteen minutes after the introduction of the poison. It is said that the virus acts directly upon the red blood-corpuscles, rendering them coherent, and thus plugging the capillaries.

FIG. 151.



Scorpion, showing curved hook at the caudal extremity.

In man the wound of the scorpion is followed by redness, swelling, and pain, all of which generally after a few hours subside. In hot Eastern climates the venom is more active, and its introduction into the body is often followed by death. The scriptural allusions to the scorpion correspond with the venomous character of the animal as found at the present day in Syria. The symptoms which follow its sting are great feebleness of the heart, a purple hue of the face and lips, vomiting, priapism, and numbness or loss of power in the tongue, with inability to control the fæcal contents of the bowels on account of paralysis of the sphincter. Violent convulsions sometimes precede death.

The tarantula.—The bite of this arachnide, a native of Italy and Syria, is much less dangerous than that of the scorpion. The current notion that it is followed by a species of intoxication, resulting in an uncontrollable desire for dancing, no doubt grew out of the custom among the laboring classes of Italy, of exciting a free sweat by protracted dancing,† to cure intermittents, common in the harvest season when such bites are most frequent.

Centipedes.—These belong to the order *Myriapoda*. The centipede is found in portions of Southern Europe, and in this country is met with in Texas and other Southern localities. The animal is of a cylindrical form, with numerous articulations. The anterior feet terminate, each, in a hook or claw, which connects with a poison-gland. The animal is capable of inflicting a wound and introducing a poison which is followed by considerable irritation and may result in death. The symptoms are a severe burning pain, swelling, and redness, with a central dark discoloration, in the injured part, followed

* Jour. de Méd. vét. de Lyon, 1852, t. viii. p. 191.

† Holmes's System of Surgery, vol. i. p. 676.

by inflammation of the lymphatics and lymphatic glands in closest relation to the damaged tissues, and the appearance of dark purple spots. The constitutional symptoms are, pains through the extremities, nausea, vomiting, dizziness, headache, and feeble and irregular pulse, occasionally followed by death.

TREATMENT.—The treatment of all these wounds—whether the irritant be a specific poison or a salivary secretion, or whatever the vulnerating instrument—is very much the same. No single remedy appears to act more efficiently than aqua ammoniæ. In one of the cases reported by Dr. Semple, in which a fatal collapse was threatened, the above remedy was thrown by means of a hypodermic syringe into the blood through the walls of a vein, with immediate relief. Should there be much general disturbance of the system, brandy and ammonia internally are the best remedies.

In the case of the scorpion wound, Dalange, as stated by Bollinger,* advises the immediate application of a ligature above the point stung, and over it several free incisions, the bleeding from which is to be encouraged by suction with the mouth. When the bite is that of the scolopendra, or centipede, Sébastiany, as quoted by the same author, advises the internal administration of carbolic acid and chloral, with external astringents.

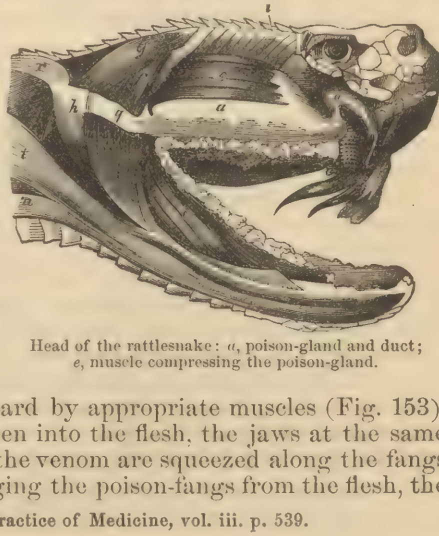
FIG. 152.

An enlarged view of the poison-fang of the rattlesnake: *pp*, cavity of the tooth; *vv*, the groove for conducting the poison.

The centipede is sometimes brought to Eastern cities concealed in hogsheads of sugar. I have seen a stevedore suffer for weeks from violent local and constitutional symptoms in consequence of a sting received on the hand while handling one of these hogsheads on the wharf. The fingers remained purple, and the hand and arm weak, for a long time. His general health was seriously impaired by the injury; and when I last saw him he looked like a man who had passed through a tedious and wasting spell of sickness.

Wounds by Venomous Snakes.—Another class of dangerous wounds are those produced by poisonous serpents. Snakes belong to the class of *reptiles*. In the United States, while there are many varieties of snakes, the number of venomous ones is quite limited, consisting chiefly of the crotalus, or rattlesnake, the elaps, and the trigonocephalus, or copperhead. In India the cobra is the most poisonous snake, and in England and on the Continent, the viper.

FIG. 153.



Head of the rattlesnake: *a*, poison-gland and duct; *e*, muscle compressing the poison-gland.

The poison-apparatus consists of a pair of recurved fangs, either tubular or grooved on the concave surface (Fig. 152): these, in the passive state of the reptile, are folded horizontally against the upper jaw and concealed in duplicatures of the gum. The poison is secreted by two glands situated behind the eye, the excretory ducts of which lead to the base of the fangs and are encompassed with a strong compressor muscle, there being no intermediate receptacle or sac for the poison. When the rattlesnake is about to bite, the body is thrown into a coil, the head becomes erect and is thrown back, and, as the jaws open, the fangs are carried forward by appropriate muscles (Fig. 153), and, when the reptile strikes, are driven into the flesh, the jaws at the same time closing, by which a few drops of the venom are squeezed along the fangs into the deadly puncture. In disengaging the poison-fangs from the flesh, the

* Ziemssen's Cyclopædia of the Practice of Medicine, vol. iii. p. 539.

wound, first made as a puncture, becomes somewhat ragged or lacerated. The poison of the rattlesnake has been very carefully studied by Dr. S. Weir Mitchell, of this city, whose elaborate and exhaustive monograph upon the subject* deserves to rank with the great work of Fayrer on the Thanatophidia of India. The virus is a thin, albuminous, almost transparent fluid, sometimes having a shade of green; it has neither smell nor taste; its reaction is acid; it has a specific gravity of 1044, coagulates at a temperature of 140°, and becomes solid at 160°. The amount of venom usually contained in the gland or ducts does not exceed a few drops. Whether the animal is torpid or not, the virulence of the poison is never lost; though it is most intense during the warm season or when the reptile is most active. Its power to retain its deadly property is well shown by the fact that its activity was not in the least impaired by acids or alkalies, chlorine, bromine, boiling, freezing, or drying. The poison of the cobra, according to Shortt,† is rendered inactive when mixed with potash. Under the microscope numerous cells are seen floating in a liquid. Its chemical constitution consists of an albuminous body, *crotaline*, not coagulable by heat at 212°; an albuminoid compound, coagulable at the above temperature; coloring matter, with an undetermined substance, both of which are soluble in alcohol; and a trace of fatty matter, together with salts, chlorides, and phosphates.

Venomous snakes of the same species cannot poison one another, but those which are not venomous enjoy no immunity. Warm-blooded animals succumb most quickly to the poison. The bite of the copperhead is much less dangerous than that of the rattlesnake: indeed, I have never known an instance of the former to prove fatal. In India, according to Fayrer, with a population of one hundred and twenty millions, eleven thousand four hundred and sixteen deaths from snake-bite alone occurred in a single year. The cobra de capello and the rock snake are the reptiles which produce this mortality.

In Africa, snakes of enormous size and of exceedingly venomous character are described, which are said to be sufficiently bold to chase their victims with a speed which defies escape. In the little company of Susi and Chuma, which was bearing the remains of the lamented Livingstone to Bogamoio, was a little girl named Losi. While passing through a rocky place, this child, carrying a water-pot on her head, was attacked by a snake called by the natives a mampa. The reptile dashed across the path and struck her upon the thigh. Though every effort was made in her behalf, in less than ten minutes the child expired. A few days after, a similar scene was enacted at the same spot, and most probably by the same snake; the victim being in this instance a stout adult male native.

Symptoms.—The symptoms following snake-bite are both constitutional and local.

The constitutional effects are those of a tremendous shock, faintings, terror, nausea, trembling, and extreme depression. These are followed by numbness, stupor, and incontinence of urine and fæces, with a clammy perspiration. The action of the heart becomes weak, the respiration slow and oppressed; the skin icterode; and the patient may die within half an hour, or, where the fang has penetrated a vein, in a few minutes. In a case which occurred in the practice of Dr. Shapleigh, of this city, death followed in three-quarters of an hour.

The local symptoms consist of agonizing pain, a rapid and extensive ecchymosis or hemorrhage, and swelling of the entire limb, which becomes covered with blebs, is mottled, cold, livid, and rapidly passes into a state of gangrene. When the case is slow in its progress, the inflammation may assume the condition of phlegmonous erysipelas, the serous transudation rendering the part œdematous, or, when the transudation partakes of a fibrinous character, hard and dusky-red in color. The absorbents of the part also become inflamed, and the glands in which they terminate are enlarged.

* Researches on the Venom of the Rattlesnake, Smithsonian Contributions, 1861.

† Experiments with the Poison of the Cobra-de-Capello, Lancet, 1868, pp. 556, 615.

Post-mortem appearances.—The examination of a case of fatal snake-bite reveals extensive engorgement of the right heart, of the brain and its membranes, and of the kidneys, lungs, and liver, the blood being dark and imperfectly coagulated. There is also present ecchymosis of the thoracic and abdominal viscera. The remarkable transudation of the blood witnessed by Mitchell, due doubtless to an altered condition in the physiological character of the vascular walls, may throw some light upon a somewhat similar process in inflammation. The effect of the venom appears to destroy at once the vitality of the blood, rendering it unfit for the supply of the nerve-centres, and thus depriving the heart of that force which is necessary for the work of the circulation.

Treatment.—The indications in the treatment of snake-bite are, first, to prevent the entrance of the venom into the circulation; second, to effect its extraction; third, when these objects have not been attained, to support the system until the elimination of the poison takes place.

To accomplish the first, that of preventing the poison from entering the blood-vessels, a cord should be instantaneously thrown about the part above the wound and drawn sufficiently tight to arrest the circulation at once, and then the part should be excised, the incision being carried much beyond the limits of the wound. After the operation the flow of blood should be encouraged by suction with the mouth, in order to effect the second indication, namely, that of extracting the poison. Should there be no crack or ulcer on the lips or in the mouth there will be no danger in adopting this plan, as the poison may be swallowed with impunity. If the finger or toe be struck, it will be best to resort to immediate amputation. That excision can be successfully practiced without previous constriction will appear from the following case recently narrated to me by a medical friend.

He had gone into Western Pennsylvania during the summer, in order to establish some lines of old surveys. While lunching at noon, he and two of the woodsmen went to a spring, close at hand, to slake their thirst. One of the men threw himself down upon his hands and knees to drink directly out of the pool, when he was struck on the fleshy part of the bare arm, a short distance above the wrist, by a rattlesnake, which had been lying concealed in the leaves and had been touched by his hand. The doctor was so terrified at the sight as to be completely stupefied and rendered incapable of making a single effort for the life of the man. Not so, however, with his hardy and ready-minded companion. The wounded man instantly shook off the reptile (as did Paul the viper which came out of the fire and fastened on his hand on the island of Melita), whilst his companion, quick as thought, unclasped his knife, and, pinching up the flesh, removed at one sweep a large mass from the arm and covered the bleeding surface with a quid of tobacco: all this was done before my friend had even recovered from his bewilderment. No evil effects were experienced, and the woodsman continued his work as though nothing had occurred.

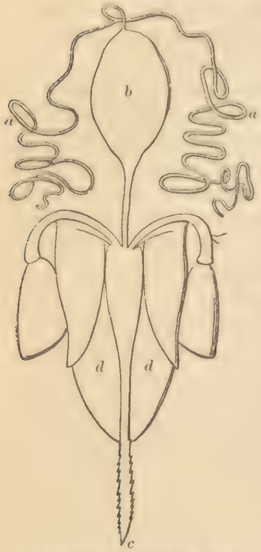
When the constitutional action of the poison has commenced, the case resolves itself into one of stimulation. The various remedies which have been brought forward from time to time and vaunted as specifics, such as olive oil, bromine, the Tanjore pill, Bibron's antidote,* and others, are powerless for good. The subcutaneous injection of equal parts of aqua ammoniæ and water, as near the wound as possible, has been strongly recommended by Halford, though not regarded with much favor by the physicians of India, where it has been much employed. Alcohol is the most reliable remedy. In several cases treated by Drs. Cooper and Getty, both surgeons in the United States army, this was the only agent employed. It must be given early, and in large doses, in order to induce a condition of intoxication; and the amount necessary to effect this is almost fabulous. In one of Surgeon Cooper's cases it required for this purpose one bottle of brandy and one and a half bottles

* Bibron's antidote consists of potash, corrosive sublimate, and bromine.

of whisky; and in another, two bottles of proof Bourbon whisky.* Should the patient be unable to swallow, the whisky or brandy must be given by the rectum. Alcohol, however, does not act by neutralizing the poison. Mitchell has shown that it simply sustains the action of the heart until the poison or its effects have been either exhausted or eliminated from the system.

Poisons derived from Insects.—There are a number of insects which inflict upon man wounds of a poisonous nature. These belong to the order *Hymenoptera*, such as the bee, wasp, hornet, and yellow-jacket. The poison is secreted in glands situated in the abdomen of the insect, which empty into a sac communicating with the sting. (Fig. 154.) When the insect is irritated, the sac is compressed by means of a muscular apparatus and the sting protruded beyond its covers, by which a puncture is made and an exceedingly small amount of the poison conducted into the wound. In its withdrawal the sting, in consequence of its serrations, is frequently detached from the body of the insect, and remains in the wound.

Fig. 154.



The poison-apparatus of the bee: *a, a*, tubular glands for secreting the poison; *b*, receptacle; *c*, sting; *d, d*, sting-covers.

Symptoms.—When a sting is inflicted, a sharp, burning, and itching pain is experienced, followed by indurated welts or wheals, the centre of which is pale and the circumference red, not unlike the eruption of measles. Generally the injury proves harmless, the pain, swelling, and redness disappearing in the course of a few hours. Should, however, such wounds be greatly multiplied, as when an individual is attacked by a swarm of bees, they may prove fatal. Death has followed the sting of even a single bee.† Such wounds are not free from danger when inflicted about the eyes, lips, tongue, or mouth; as the rapid tumefaction which follows in loose extensible structures, like the tongue or the parts about the top of the larynx, exposes the patient to the risk of suffocation. There are recorded instances in which death has followed in a few minutes after the injury, in consequence, it is supposed, of the sting having penetrated a vein and conveyed the poison directly into the blood. In persons of a very impressible organization, who have been stung, it is not uncommon to witness nausea and vomiting, and sometimes symptoms of collapse.

Treatment.—The part should be examined for the sting, which is often left in; and, when this is the case, it should be extracted with a pair of delicate flat-bladed forceps. A solution of sugar of lead applied to the wound is a very good remedy. Dilute carbolic acid (one part of the acid to nine parts of the water, or, still better, with eight parts of olive oil) is frequently employed with marked relief. The application of salt and water, of hartshorn, or of spirit of camphor, will also be found efficacious. These all appear to neutralize the poison. A very popular and soothing remedy in domestic practice consists in the application of wet clay, which should be employed when other means are not at hand, renewing it as often as it becomes dry. When there is great swelling of the tongue, or œdema at the top of the larynx, threatening suffocation, as may happen when a bee is taken unobserved into the mouth with honey and inflicts a sting, free incisions should be promptly made to empty the loaded tissues.

There are other insects—as the bed-bug (*Cimex*), the flea (*Pulex*), and the mosquito (*Culex*)—capable by their bite of producing much irritation, not

* Smith's Surgery, vol. i. p. 445.

† New York Journal, May, 1857; also, Medical Times and Gazette, 1860, p. 389, and British Medical Journal, April 24, 1869, p. 374.

from the contents of poison-glands, but from the salivary secretion, which is formed from tubular glands floating in the body of the insects. The treatment of their bites does not differ from that proper to the sting of the bee.

Gunshot Wounds.

Terrible as are the evils of war, medicine and surgery have done much to mitigate the distress and suffering incident to its conflicts. The events of the last few years have afforded American surgeons opportunities on a very extended scale for the study of gunshot injuries. The improvements in modern arms and missiles have materially modified the nature of these casualties. Among the old military surgeons, these wounds were invested with peculiar characteristics, acquired, it was thought, from the explosive nature of gunpowder: they were regarded as poisoned wounds, and, it was believed, had to be subjected to a long and tedious process of irritation and suppuration, by incisions and stimulating compounds. It is only within the last seventy-five years that any material advance has been made in the management of these injuries. The slow improvement of English military surgery, according to Hennen, was to be attributed to the indifference, neglect, and even contempt, with which professional men were formerly treated by the governments under which they lived. This was in striking contrast with the esteem in which army surgeons were held in ancient times. Among the Greeks, the physicians who accompanied armies into the field were regarded as worthy of the highest consideration. At the siege of Amiens, in 1597, field hospitals were first established; and, as such an event rendered it necessary to provide professional assistance, we may refer to the reign of Henry IV. of France the commencement of a better day not only for military surgery but also for the humane treatment of soldiers. This early effort to supply a place for the reception of those who were wounded in battle culminated in the construction and support, by France, of the Hôtel des Invalides,—the glory of Louis XIV.; and in England, about the same time, of the Chelsea Hospital. An outgrowth of these provisions for the sick and wounded, on the Continent at least, was the establishment of military schools for medical and surgical instructions. There have been times in which the presence of a surgeon was necessary to secure the success of a campaign. The feeling that relief is at hand, in the event of accident or injury, is a powerful stimulus to the courage of soldiers. The besieged garrison of Mentz owed its deliverance more to the personal influence of the surgeon of Henry IV., Ambrose Paré, than to French valor. There were critical periods during the wars of the first Napoleon when the presence of Baron Larrey exercised an influence on the army not inferior to that of the Emperor himself.

The treatise of John Hunter on the "Blood, Inflammation, and Gunshot Wounds," published in 1794, was one of the earliest contributions to military surgery in England. The genius of this great man enriched everything that it touched; and although a more extended experience has shown that in some points his views required material modification, yet in the main the principles which he enunciated were correct. What may be considered the errors of Hunter were corrected by Guthrie during the Peninsular War. This last-named surgeon, from a large experience, was enabled to demonstrate the superiority of primary over secondary amputations, and the propriety of amputation at the shoulder- and hip-joints, also to indicate the proper course to be adopted in cases of gangrene from injured vessels, and in phlegmonous erysipelas. The military campaigns of Napoleon were scarcely more important in a political point of view than were the writings which embody the accumulated experience of Larrey in establishing modes of surgical treatment which were advantageous to human life. The Crimean War, whatever it may have accomplished for the peace of the world by the success of the allied arms, furnished at least the materials for testing satisfactorily

vital surgical questions; and these materials have been placed in a permanent and available form by Macleod and D. Chenu. The same may be said, to a certain extent, of the later and more decisive wars which have been waged in Europe, as that between Austria and Prussia, and that between France and Germany. In all these struggles, the medical and surgical history of the conflict, under the fostering care of the respective governments,—after the example of England,—became an integral part of the service. And, lastly, in the War of the Rebellion in the United States, the government assumed the responsibility of preserving to the world the medical and surgical treasures of that fratricidal conflict.

The character of arms and projectiles.—Gunshot wounds may be inflicted by a great variety of missiles. The mere explosion of powder from the muzzle of a gun, at close range, will produce a serious injury, one which will combine the characters of a burn with those of contusion and laceration. Our hospitals furnish numerous examples of such accidents in consequence of the use of fire-arms by reckless boys. I have seen a person instantly killed by a heavy discharge of powder when close to a gun. Suicidal attempts are sometimes made by discharging a pistol, charged with powder alone, into the open mouth: the laceration and bruising which follow may eventuate in death, from œdema of the larynx, or from blood-poisoning consequent on sloughing. When a wad is added to the charge, the danger is increased, and at short range the former may enter the body. Life has been lost in several instances in this way during sham fights.

It is by powder and wadding that quarrymen are so often wounded from the premature discharge of a blast.

Shot, when received at close quarters, make a wound not unlike that produced by a large musket-ball, inasmuch as the charge moves for a short distance almost in a solid mass. I was once called to see a young lad who, in the act of dragging a gun muzzle foremost through a fence, disturbed the hammer and discharged the contents of the piece into his arm. The charge consisted of bird-shot, and entered a short distance above the wrist on the anterior part of the arm. There was but a single opening, like that made by a ball, with inverted, ragged edges. If a load of shot enter a part just as the individual grains begin to separate, the wound will be cribriform. It occasionally happens that the heat developed in the combustion of the powder will partially melt the leaden shot and weld them into a solid mass, forming a bullet with an irregular and granular surface. Such a condition is seen in Fig. 155, taken from a specimen in my possession. Fragments of metal or wood, buttons, pieces of coin, portions of clothing, splinters, slugs, nails, and gravel-stones are not unfrequently driven into the body, producing fearful lacerations.

Fig. 155.

A charge of shot united by the heat of the exploded powder.

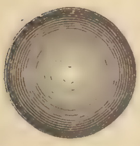
The two great modern improvements in the construction of arms and projectiles consist in the adoption of rifled guns and cylindro-conoidal balls. Such changes have increased immensely the range of these weapons, rendering them capable of inflicting fatal wounds even at the distance of a mile. Dr. Brinton informed me that he witnessed, in front of Petersburg, a soldier shot through both thighs, by an ordinary Minié ball, at the distance of one mile, which broke both femurs and inflicted a fatal wound.

The arms in common use are the Sharp, Enfield, Chassepot, and needle gun. Some of these are breech-loaders. The same principle observed in the construction of small arms, namely, that of rifling the bore and changing the form of the missile, has been applied to guns of large size: so that an Armstrong gun will project a ball with considerable certainty to the distance of five miles.

Balls are of three kinds,—the round, cylindro-conoidal, and egg-shaped. The old round ball was at one time formed of stone. At the Castle of Edinburgh may be seen a monster cannon (Mons Meg) with a stone ball attached.

Some of the balls used three hundred years ago weighed eight hundred, and some even eleven hundred, pounds. For the time, such projectiles were quite formidable in the work of destruction. In 1453, Mahomet II. battered the walls of Constantinople with stone missiles.

Fig. 156.



Old round United States musket-ball.

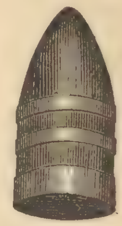
Fig. 157.

Springfield rifle ball.

Fig. 158.

Enfield rifle ball.

Fig. 159.



Austrian ball.

The old round musket-ball (Fig. 156), as used by the English, French, and Russians, weighed from a trifle less than one ounce to one ounce and a half, the heaviest being that employed by the Russians. The musket-ball used by the United States government weighs 387 grains; calibre .69.

Cylindro-conoidal balls differ considerably in size and weight. The Springfield rifle ball (Fig. 157), calibre .58, weighs 500 grains; the Enfield rifle ball (Fig. 158) for the muzzle-loader was formerly 530 grains, but for the present breech-loader is about 450 grains; the Austrian ball (Fig. 159) weighs 400

Fig. 160.

Fig. 161.

Fig. 162.

Fig. 163.

Fig. 164.

Fig. 165.

grains; the French Minié ball, 680 grains; the French Chassepot ball (Fig. 160), 380 grains; the needle-gun ball is egg-shaped (Fig. 161), and weighs 530 grains; the ball of the mitrailleuse is longer than the others, and weighs one ounce and three-quarters (Fig. 162); the Martini-Henry ball (Fig. 163), recommended for the British infantry, and made of lead hardened with tin, weighs about 428 grains; the Russian ball is heavy, and weighs one ounce and six drachms. Other conical balls are in use, as the Bavarian (Fig. 164), and that of the Snider gun (Fig. 165).

Pistol-balls are generally conical, and at short range are quite as dangerous to life as those of larger arms.

These missiles are sometimes charged with detonating powder, like that contained in percussion-caps, and are then designed to explode after entering the body. These have, I believe, by common agreement of nations, been withdrawn, as inconsistent with the spirit of modern warfare.

Cannon-balls.—These, like the projectiles for small arms, are either round or cylindro-conoidal. They are made of iron, and weigh from one to one hundred pounds. The latter when fired from a rifled cannon, like the Armstrong gun, prove effective at the distance of four or five miles.

Shells are hollow spheres filled with gunpowder, and sometimes, as in the

shrapnel shells, with both powder and balls. The explosion of these missiles, sending fragments in all directions, sometimes does fearful execution. The Duke of Wellington, however, thought shrapnel shells of very little importance, rarely disabling any one.

Grape-shot consists of three layers of cast-iron balls contained in canvas, disposed about a central pin of wood, and secured together by a cord. The resemblance to a bunch of grapes explains the origin of the name.

Canister-shot is composed of small cast-iron balls mixed with sawdust and contained in a tin case, which is closed at each extremity.

The effect of a change of form and the resulting momentum is to confer on the cylindro-conoidal ball a power of penetration far greater than that of the old round missile. As compared with the latter it is less likely to lodge in the body. Even at the distance of eight hundred or one thousand yards it will pass completely through a part, and at a shorter distance through three or four persons who may be in range.

The wounds which it produces are more severe. The destructive effects of the conical projectile are best seen in shot-wounds of the long bones. If the momentum is not materially diminished it will pass through, making a simple perforation; if, on the contrary, its velocity has been in some degree spent, it will split and comminute the bone in a frightful manner. (Fig. 166.) Not only is this the case, but the concussion will extend far beyond the limits of contact or fracture, laying the foundation for subsequent inflammatory processes, such as osteomyelitis, which may involve the life of the entire bone. The case is very different with the old round ball, which passes through a bone, either making a small hole or breaking it into a few irregular masses. Oftener it merely penetrates into the cancelli, or is flattened against the bone and remains in the tissues. In the case of wounds of the soft parts the difference is quite marked between the effects of the two projectiles. The cylindro-conoidal ball, moving at a marvelous velocity, destroys thoroughly the vitality of the parts for some distance around its track, so that sloughing follows to a much greater degree than after wounds by the old round missile.

FIG. 166.

Comminuted fracture of femur produced by a conical ball. Spec. 5489, U.S. Army Medical Museum.

Again, the cylindro-conoidal ball is much less likely to be turned out of its course or deflected. This is not to be ascribed to the mere momentum alone, but also to its form and axial revolution. The eccentric course of a deflected ball is a curious fact. A very trifling circumstance may determine it, such as the angle of contact, a tendon, a muscle in a state of contraction, a piece of coin, a handkerchief, or some other object. A ball so changed in its course may follow a very circuitous route. It may enter the front surface of the chest, follow the curve of a rib, and pass out opposite, at the side of the spine, or remain among the muscles of the back, thus making half the circumference of the thorax; or, striking the forehead, it may follow the convexity of the cranium and lodge or emerge at the occiput. Hennen gives six fatal cases in which balls followed the concave or pleural surface of the ribs. In two of these the bullet entered on the right side of the sternum, and, passing between the lungs and the pleura costalis, traversed the left side, escaping at the spine. In two other cases the ball entered the abdomen near the umbilicus, and, running between the parietes and the viscera, made its exit at the side of the spine directly opposite.*

* Hennen's Military Surgery, p. 37.

The same author relates the case of a friend, in whom the ball entered over the thyroid cartilage, made the entire circumference of the neck, and was found lying in the wound of entrance. Ballingall* mentions a case which had been related to him by Mr. Gulliver, in which a musket-ball entered the posterior part of the thorax, followed its concave surface, and was found lodged in the inner surface of the sternum. It is this circuitous route of balls which leads often to the hasty and erroneous conclusion that a cavity has been directly crossed by the projectile. The manner in which balls pass through the body without damage to blood-vessels, nerves, or viscera is very remarkable. It was not uncommon during the War of the Rebellion to meet with instances in which a bullet went through the neck or axilla at the portions most crowded with structures essential to life, with impunity; and examples are cited of balls traversing the abdomen without damage to its contents.

When a deflected ball takes a circuitous course under the skin, its track will sometimes be revealed by a red wheal or discoloration beneath the skin, made by the extravasated blood finding its way to the surface.

Openings of entrance and exit.—Whether the projectile be round or cylindro-conoidal, the opening made in entering is smaller than that made in leaving or passing out of the body. The opening of entrance is usually smaller than the ball, owing to the elasticity of the skin. The edges are generally inverted, perhaps ecchymosed. If the ball be round, the opening will have very much the same form; if conical, it may be irregular, slit-like, or cruciform. The opening of exit will be larger, often lacerated, and the edges everted. This is just what occurs in firing a ball through a board, or even in driving a nail through the same. In the old round ball, as well as in the conical, the degree of difference between the relative sizes of the openings of entrance and exit will be in a great measure determined by the momentum. Should the projectile enter the body with undiminished velocity, and pass through, the difference in diameter between the orifice of entrance and that of exit will not be great. If, however, the momentum has been diminished by atmospheric resistance and the attraction of gravitation, or by the resistance encountered in passing through a part, or by all these combined, the openings of entrance and exit will both be comparatively large, especially the latter, inasmuch as the ball in escaping is not only passing from a denser into a rarer medium, but it is the ball, plus a certain quantity of displaced tissue, which must be accommodated. It is the operation of these causes which determines the eversion of the edges of the opening of exit. There are exceptional circumstances which serve to make the opening of entrance the larger of the two, as where the ball carries with it some foreign body and buries it in the flesh. Every author on military surgery gives examples of this nature. Hennen mentions an instance in which a projectile carried a piece of the cranium of one soldier and produced by it a large lacerated wound in the thigh of a second; another in which the wound of entrance, situated in the thigh, was magnified by a portion of the ulna with its olecranon process; and still another in which a tooth was carried along with the ball and lodged in the temple of a soldier. Hamilton relates a case in which a number of teeth with a ball were removed from the neck above the sternum. I have seen a similar effect produced by a part of an officer's saddle being broken off and driven before the ball into the thigh. A conical ball in the course of its flight may be so altered in position as to enter the body with its long axis parallel to the surface, thus making a large, ragged wound of entrance, and, by encountering a certain kind of resistance in its passage, may have its direction so changed as to emerge apex foremost, making the wound of exit smaller than that of entrance. It is possible for the opening of entrance to be also that of exit. Such cases are certainly very rare; but the possibility of their occurrence is shown in the case related by Hennen, in which a ball, after passing round the neck, lay in the opening of entrance; or it may occur in another way, by the projec-

* Outlines of Military Surgery, p. 209.

tile striking a bone and rebounding through the opening made in entering. A single ball may make two openings of entrance and a like number of wounds of exit, as where the forearm is flexed upon the arm or the leg upon the thigh at the time of being struck by a ball, in which position the missile may pass through the forearm or thigh and afterwards enter and pass through the arm or leg. There may be a single point of entrance and several of exit. This is likely to be the case when a ball on entering strikes some salient object and is divided into several fragments, each of which in passing out makes an opening for itself. Larrey and Guthrie furnish each an example in which there were six openings of exit. Again, there may be two or more openings of entrance and one of exit produced by the ball striking some object on which it is split into two or more pieces, each entering the body by a separate opening, while one only has sufficient momentum to pass out.

Change which the ball undergoes after leaving the gun.—A ball traveling with sufficient momentum to pass through a part, and making only a flesh-wound, will be very little changed in figure or appearance. Especially is this true of the conical bullet, which is more solid than the round one, being compressed into form, and not cast in a mould, as was the old spherical projectile. There is usually on one side of the base of a ball which has been fired, an oblique or flattened surface, supposed to be due to the manner in which it leaves the gun. When a round ball strikes point-blank against a resisting body like bone, it will be flattened; if conical, the point will be blunted and the body often bent upon itself, contorted, or changed into an irregular, shapeless mass. If only a portion of the conical extremity strikes against the metal of the soldier's accoutrements or against bone, it will be planed, leaving a smooth facet on one side. The dividing of balls into several pieces is usually produced by the encountering of solid objects before entering the body. Examples of balls altered in form by impact are shown in Fig. 167, kindly furnished by the Surgeon-General U.S.A.

Fig. 167.

Balls with little momentum.—The effect of diminished velocity on rifle-balls has already been noticed,—that of causing deflection or lodgment in the body. Studied in connection with cannon-balls, this effect is very remarkable. Such a projectile, moving at great velocity, will produce the most fearful destruction of parts, carrying away a limb, leaving the soft parts hanging in shreds and the shattered bones protruding below, or, if the contact be less direct, sweeping off the flesh to the bone, and yet perhaps not prostrating the individual. When the momentum of such a ball is largely expended by the conjoined influence of atmospheric resistance and gravitation, or by ricochet, it is by no means disarmed of its power to do harm, though rolling slowly over the ground; and when we consider the amount of force that is necessary to move so great a mass of metal even at this slow rate, together with the weight itself, it is not difficult to understand those cases in which a foot has been hopelessly destroyed by thoughtlessly placing it against such a body with a view to arrest its progress. The capacity of such a ball to produce the most extensive bruising, or even laceration, of internal organs, without leaving any external marks of violence, is well known. This at one time was attributed to what was called *windage*,—that is, the sudden condensation and expansion of the air as the ball passed close to the body. Such

was the explanation given by Forbes,* of Edinburgh. Mr. Ellis thought it was produced by electrical changes caused by the rapid flight of the ball. Guthrie's explanation is doubtless the correct one. He considered that a low instead of a high rate of velocity of the ball, and actual contact instead of contiguity, were required. When the momentum is in a great measure expended, the ball rolls on its axis over the surface like a wagon-wheel, and this determines the internal damage of organs whose texture is not very strong, whilst the skin, from its great elasticity, presents little evidence of injury.

Character of gunshot wounds.—Wounds made by balls are both contused and lacerated, and they heal by granulation. Even when the vulnerating projectile is fragmentary, as a split ball or a portion of an exploded shell, the parts are scarcely ever divided after the manner of an incised wound. In consequence of this, such injuries are followed by sloughing, and in most instances throughout the entire length of the tract, though not to the same degree in all parts of the body. Usually the circumferential extent to which the vitality is destroyed will be greatest about the point of entrance, diminishing gradually from this to the orifice of escape; that is to say, the death will be most extensive where the velocity of the projectile has been greatest. This explains the fact that the opening of entrance frequently becomes, in a few days, larger than that of exit. If we study closely a gunshot injury, the structures in the neighborhood of the wound will be found to differ in their appearance. For a short distance around the opening made by the ball the parts will be bruised, compacted together, and of a pale-red color. Nearer the circumference, in a short time, an inflammatory process will be found at work infiltrating the parts with a transudation of fibrinous matter and cells; and, still farther out, there will be an increased afflux of blood, with an œdematous condition, due to the presence of serum. In this inner circle we recognize structures so pulpified that they must be cast off as a slough; in the second, a work of separation, suppuration, and the materials of reconstruction, or granulation-tissue; and in the outer, or third, an area of blood-determination.

Relative frequency with which different parts of the body are wounded.—Zetzell, in speaking of the portions of the body most frequently injured by balls,† has given the following estimate: for every two persons shot in the belly, there will be three or four wounded in the neck and breast, seven in the head, ten in the arms and hands, four in the hips, five in the legs, one in the knee, and two in the feet. All such calculations, however, come short of the truth, and are subject to great variations from different circumstances, as the nature of the ground or of the defense, and the relative position occupied by contending bodies of troops. In the late War of the Rebellion the position of the wounds differed very much in different engagements.

Symptoms.—These are *local* and *constitutional.*

The *local symptoms* vary much, according to the position, structure involved, extent, and personal peculiarities. Many wounds are received without the person being even conscious of the fact. A soldier, in the heat and excitement of a closely-contested battle, may forget the injury until the day is lost or won. General Hancock, at the critical battle of Gettysburg, though he received a dangerous wound of the thigh, was for some time unconscious of the injury. Usually, however, there is a feeling of a sharp blow, a sting, a warm sensation, or a sense of numbness. An examination reveals the hole made by the bullet. If a nerve be touched, the pain may be exquisite, and compel the strongest man to cry out. The suffering is sometimes experienced in a part remote from the injury, as in the arm after a wound of the neck injuring the brachial plexus of nerves. Where a bone is broken, the pain is usually severe. When a ball divides an important nerve, like the median or the sciatic, there will be loss of power in the parts supplied by these trunks. When a bullet passes through the brain, the wounded man will, if making a charge at the time, fall forward to the earth. When struck in other parts

* Edinburgh Journal for 1812–13. † Hennen's Military Surgery, p. 31.

of the body, the soldier may stagger, yet recover himself, or he may reel and fall to the ground. On the battle-field of Gettysburg many of the slain lay upon the back.

Hemorrhage.—Hemorrhage may be primary or secondary. Most persons who die on the field perish from this cause. Where vessels of small size are divided by a ball or other missile, or where a limb is torn away by a cannon-ball, there will be little bleeding, the coats of the vessels being lacerated and twisted, conditions unfavorable to hemorrhage. Where a large trunk is torn, like the femoral, carotid, or subclavian, the bleeding will be profuse from both the wound of entrance and that of exit. The danger will be less if at the time of the injury the vessel be completely severed, as the ends are thereby enabled to contract within the sheath, thus favoring the formation of a clot both in the surrounding tissue and within the lumen of the artery. A wound may not bleed at the time of its reception, yet after reaction may pour out a serious and perhaps fatal amount of blood. There is also a concealed hemorrhage following penetrating wounds of the chest or abdomen, which is dangerous because out of sight. There may be a concealed bleeding even in wounds of the extremities, due to the circuitous route of a ball or to a change in the relation of parts after the reception of the wound. I witnessed such a case in a young man who had accidentally shot himself through a portion of the calf of the leg in which no vessels of importance could have been injured in the ordinary extended position of the member, yet a quiet hemorrhage had been going on for some time, forming a large collection in the limb, without a drop flowing externally. Internal hemorrhage is indicated by prolonged shock, pallor, and nausea.

Secondary hemorrhage.—This is a common sequence of gunshot wounds. Vessels are frequently contused or grazed by the passage of a ball, and subsequently the parts die and separate as a slough, giving rise to secondary bleeding. It may follow sloughing of the contiguous parts, in which the artery becomes involved by extension of the disease, or it may be due to a spiculum or sequestrum of bone or a fragment of shell changing place and wounding a vessel. Secondary hemorrhage occurs from the sixth to the fourteenth day after a wound, though it may be delayed several weeks, and in a case given by Chisholm three hundred and twenty-eight days elapsed before its appearance. When secondary hemorrhage takes place, it is ordinarily without premonition; there is a sudden outburst of blood, which may prove almost instantaneously fatal, but more commonly induces fainting, by which it is temporarily arrested.

Constitutional Symptoms.—The dominant constitutional feature of a gunshot wound is *shock*. The degree of shock present is subject to great variations, from peculiarities of mental and physical organization as well as from the nature of the part involved. One man will have a limb carried away or suffer extensive laceration of structure, and yet betray little if any perturbation, while another, with a wound of trifling significance, will grow faint and deadly pale, his skin will become wet with a cold perspiration, and vomiting and tremors may follow, with such great mental agitation as frequently to assume the form of delirium or hysterical raving. This "shock," however it may be modified by physical and mental conditions, is, as a rule, determined, both as to continuance and degree, by the severity of the injury. When a ball traverses a cavity and wounds an important organ, or crashes through a large joint like the knee, breaking the bones into pieces, it will be well pronounced. Even when wounds appear unimportant, we may measure their danger by failure or delay on the part of the patient to react. Many wounded men die of shock, either on the battle-field or after their removal.

Prognosis.—There are so many contingencies which may befall wounded men that it is very difficult to forecast the result of any given case. The slightest scratch may be attacked by erysipelas and terminate fatally in one person, while another may struggle successfully through the most serious injuries of the brain or chest. General Mitchell, after encountering the

dangers of many hotly-contested fields unharmed, finally died from a trifling abrasion of the skin over the tibia, received in stepping from a boat at Pittsburg Landing. Hospital gangrene or erysipelas may break out and decimate a camp; pyæmia, especially where the bones have been extensively damaged or much blood lost, destroys many men; secondary hemorrhage adds to the mortality; tetanus will claim a certain number of victims. This last disease is most common after naval engagements, perhaps from the wounds being made so frequently by splinters. Sir Gilbert Blane states that out of eight hundred and ten wounded in the West Indies during the battle in April, 1782, twenty cases of tetanus occurred, or about one in forty.* Stromeyer informs us that one in three hundred and fifty wounded in the Schleswig-Holstein War perished from tetanus. Larrey, in his "Mémoires," says that the disease was very common among the wounded near the Nile during the campaigns of Bonaparte in Egypt. In the War of the Rebellion numerous cases were observed.

Then there must be taken into the account the hospital accommodations, which are often insufficient to receive the wounded, especially after a bloody battle. Overcrowding, insufficient hospital supplies, too few surgical assistants or nurses, unhealthy localities, and epidemic influences, with others which might be enumerated, are all subjects to be considered in venturing a prognosis. Should the patient escape unscathed from such an array of enemies, there are still others which claim no small number of victims, among which may be mentioned prolonged suppuration from bone disease, which may destroy the patient by sheer exhaustion or by developing into activity some latent weakness, like tuberculosis, kidney degeneration, or aneurism. A ball may remain long encysted, and yet suddenly become displaced and drop into the chest or brain and provoke a fatal inflammation. Old sinuses which remain open are exposed to attacks of erysipelas which may destroy life. Neuralgia also may be excited, and by its continued severity wear out the sufferer. Even if he escapes all these, there remains the possibility of paralysis and epilepsy; to which may be added deformities from inflammatory conditions of the fasciæ, tendons, and articulations.

Treatment.—The treatment of gunshot wounds is divided into *provisional* and *permanent;* or that which is proper at the time of the accident and that which is demanded after removal to a hospital or home. In military practice it is common, both with our own and with other nations, to establish, at convenient and well-sheltered points, different corps of surgical assistants, who can render prompt aid in cases of urgency, and afterwards forward the patients by ambulances and stretchers to the field- or more distant hospitals. The functions of the surgeon in this first work consist in the administration of wine, whisky, aromatic spirits of ammonia, or similar restoratives to relieve shock,—directing that the head be kept low. He is to remove any foreign bodies that are exposed to view, apply wet compresses and a few turns of a roller over the wound, or adjust a splint to a broken limb. When there is profuse bleeding, the vessel should be tied at once, or, if that be not feasible, the hemorrhage should be controlled, for the time, by a tourniquet, or by the finger of an assistant applied in the wound. Tourniquets for the most part are painful instruments if they are long retained on a limb, and are not without danger to its life. The instrument known as Lister's, figured on page 162, is the least objectionable, as the pressure operates only on opposite surfaces of the limb, leaving the venous circulation without embarrassment. In a case of great emergency, and in the absence of proper instruments or professional skill, the Spanish windlass (Fig. 83, page 161) could be used as a temporary expedient.

Permanent treatment.—When the regimental hospital is reached, then commences the permanent treatment. This may be included under the following heads: 1, the relief of shock; 2, the arrest of hemorrhage; 3, the removal of foreign bodies, which includes the extraction not merely of balls, but

* Ballingall's Military Surgery, p. 257.

also of portions of clothing, fragments of comminuted bone, and extraneous matter of whatever kind; and, 4, the control of inflammatory action and the employment of all means tending to the restoration of the patient.

1. *The relief of shock.*—Where the shock is slight, it will pass over in a short time, demanding nothing more than the recumbent position, a little warm broth, a sinapism over the præcordial region, and external heat to the extremities and spine. Where it is more profound, in addition to these measures, the head must be kept low, in order that the brain may receive a sufficient supply of blood; and diffusible stimulants, such as brandy and ammonia, should be administered by the mouth, or injected into the bowel if the patient cannot swallow. If there is reason to believe that internal bleeding exists, it will be necessary to exercise caution in establishing reaction too rapidly; accordingly, when the pulse, and the color and temperature of the skin, begin to return to the normal standard, stimulants should be withheld, or given very sparingly.

2. *Arrest of hemorrhage.*—Where the bleeding is slight, amounting only to a free oozing, elevation of the part, cold, and compression will suffice for its arrest; when from a vessel of magnitude, the artery should be sought for, by enlarging the wound, and both of the divided extremities be tied, at the earliest possible moment, as the difficulty of the operation is greatly increased after inflammatory infiltration takes place. It is far better to secure a bleeding vessel in the wound than to tie the chief trunk at a distant point. In cases where the damage is of such a nature as to require the removal of the limb, there will be no necessity for ligating vessels before the amputation, except where the condition of the patient will not warrant a resort to primary removal.

3. *Removal of foreign bodies.*—This, of course, involves the examination of the wound, which should be made at the earliest possible moment after the patient reaches the regimental hospital, in order that a correct diagnosis may be made. The patient at this time is in the very condition for such an examination. The sensibility of the wound is not acute, and there is no swelling or inflammatory alteration of the adjoining parts. While it is quite true that balls become in many instances encysted, yet even in such cases they are liable to become displaced by the movements of muscles and give rise to abscesses; or, dropping from the walls of the thorax or abdomen into these cavities, to excite fatal inflammation. Nor is there any period at which such accidents may not occur. I have removed balls which have remained quietly encapsulated for years, yet finally broke away from their beds and provoked suppuration. Professor Gross removed a ball, weighing six drachms, from the leg of a patient where it had remained for forty-nine years. Of four thousand soldiers having balls or other foreign bodies in their persons, examined by Hutin during a period of five years, twelve only had not suffered.

Since the War of the Rebellion, cases are constantly presenting themselves to surgeons in which balls have remained in the body quiescent for ten years, and then have begun to create trouble, requiring removal.

That the examination may be conducted under the most favorable circumstances, it is essential that the patient be placed, as nearly as can be ascertained, in a position corresponding to that which he occupied at the time of receiving the wound. This often gives the clue to the position of the ball. It is only in this way that it is possible to explain the character of certain wounds. A soldier, during the late war, while standing on a height and having his arm raised at full length preparatory to ramming home a charge, —his rifle being a muzzle-loader,—was shot in the back by a person occupying a lower position. The ball lodged under the skin at the back of the wrist, from which it was extracted. It had, consequently, passed the whole length of the back, over the shoulder, and along the arm to the hand. The behavior of the ball was entirely inexplicable until it was discovered that the man was loading at the moment of receiving the wound. A proper observance of this rule will convey much valuable information by enabling the surgeon

to compare the openings of entrance and exit, as related to joints, bones, great vessels, and cavities. When there is but a single opening, the inference is that the ball is somewhere in the part. The exceptional cases are exceedingly rare. Even should there be two openings, the one corresponding to that of entrance, and the other to that of exit, it does not follow that no foreign body remains in the flesh. The ball may have carried in portions of clothing, buttons, or bone, which remain, while the projectile has passed through. The best instrument for the exploration of a gunshot wound is the finger. The information which it communicates is accurate and conclusive. The finger-nail should be guarded by scraping it over a piece of soap to fill up the space beneath, that no unnecessary violence may be done to the wound. If the finger is too short, we can sometimes, by making counter-pressure with the other hand, bring the foreign body sufficiently near to be touched. By the direct use of the finger, balls, and soft substances, such as wads or portions of clothing, are readily recognized; so also may be ascertained the degree of comminution in a bone, the injury done to a joint or a cavity, and the amount of laceration in the subcutaneous soft parts. The whole question of amputation may be determined alone on the mental information acquired by the sensations transmitted from a very small surface of a finger. When the finger is too short to reach to the full extent of the wound, it must be supplemented by instrumental prolongation. For this purpose we have recourse to probes. A probe should be of silver, nine inches long, with an enlarged and rounded extremity, and sufficiently flexible to admit of its being bent so as to follow other than straight passages. (Fig. 168.) It should be

FIG. 168.

Silver probe.

used with a gentle and light hand, in order to avoid making false passages by getting out of the track, and to commit no injuries to vessels which lie in its course. As other substances—such as bone—may communicate impressions similar to those made by contact of the probe with a ball, and that operations may not be made on a mere presumption of the presence of a bullet, a very ingenious instrument was devised by Nélaton, which consists of a little ball of china or porcelain on the end of a long probe (Fig. 169), which on being

FIG. 169.

Nélaton's bullet probe.

brought in contact with lead receives a mark, or when striking against a fragment of shell takes an impression of rust, which remains on withdrawing the instrument from the wound. Other ingenious methods have been devised for a similar purpose, such as Ruhmkorff's electric apparatus, the electric probe of Favre of Marseilles, De Wilde's signal-bell, and the sounding-board probe of L'Estrange. Such complicated devices are not adapted to general use. The Nélaton probe, with all its advantages, may lead the surgeon astray, as when a ball in passing through or in grazing a bone has a portion of its lead planed off, which adhering to the surface of its track may communicate the characteristic stain to the ball. The instrument of Dr. Lecompte, by which a fragment of lead may be pinched off, was esteemed useful by Longmore and others. The articulated probes, or rubber bougies, have little practical value. When a ball is touched, the sensation communicated to the finger is that of a solid, perhaps irregular-shaped, body. Short and frequent taps will assure the surgeon of its presence. The location of a projectile is sometimes revealed by the loss of power or the painful condition of a part, showing the missile to be in contact with certain nerves. A dusky-red line and emphysematous crackling serve, in certain cases, to disclose its course.

When the balls or other foreign bodies have been discovered, the next step is their removal. For this purpose a great variety of bullet extractors, scoops, and gimlets have been invented. Of these there are two which practically supersede all others, that of Thomassin (Fig. 170), and those of Gemrig and Kolbe, which are essentially alike in their construction. (Fig. 171.) The

FIG. 170.

Thomassin's bullet forceps.

FIG. 171.

Gemrig's bullet forceps.

Grasping a ball.

Thomassin forceps are eight inches in length, with delicate blades, which are each armed at the extremity with a sharp tooth, and which are well designed to sink into and command a strong hold on a ball. The forceps of Gemrig and Kolbe differ from that of Thomassin in the possession by one blade of two branches, arranged in a fenestrated manner and terminating in short teeth. The instrument which is sometimes called Thomassin's (more properly Coxeter's, Fig. 172) is designed to fasten the ball between a fixed surface and a movable stilet, and is much more ingenious than useful. There is another bullet forceps, the blades of which can be disjoined, introduced separately, and afterwards locked. It has few advocates.

FIG. 172.

Coxeter's bullet extractor.

In using the bullet forceps it should be introduced closed and carefully conducted along the tract to the point designated by the finger or the probe until the foreign body is reached. The blades should then be expanded and made to embrace it, and when firmly infixed should be used both as a lever and tractor in the extraction of the ball. It is surprising what an amount of force is necessary sometimes to effect the removal of a ball, even when lying in the soft parts, in consequence of the fibres of the latter sinking into the irregularities of the metal. It will facilitate the removal of foreign substances if, while the finger is in the wound, any shreds or fibres of tissue which may intersect it be pressed aside, thus clearing a way for the forceps.

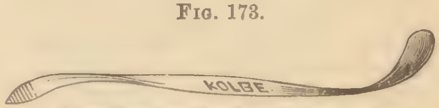
When the ball is found flattened into a distorted mass, or when the foreign body, whatever it may be, is irregular in its form, care should be observed that it be grasped in such a way that its long axis shall correspond to the course of the wound. Forcibly tearing a body through the tissues, regardless of incompatible diameters, may inflict serious damage to important structures. In the extraction of fragments of shells it may become necessary to enlarge the wound.

When a ball does not pass entirely through a part, but is felt lying either under the skin or in the muscles below on the opposite side, or out of reach through the opening of entrance, it should be fixed by proper pressure with the finger, to prevent a change of place, and then reached by cutting directly down upon it.

Portions of clothing are best detected by the finger, as are also splinters or fragments of bone, and are most easily removed by the ordinary dressing forceps. In dealing with bone-splinters or fragments, we must be guided by the extent of periosteal attachment. If a piece is entirely separated from its bony and periosteal connections, there can be only one course proper, and that is its removal at once. If a splinter is disconnected with the bone, and has a very slight periosteal connection, that is, so slight as not to exceed one-fourth of its surface, it should be extracted; when exceeding this, it is better to re-adjust it and leave it undisturbed. The idea that all such splinters, not entirely separated from their connections with the bone, should be pressed into place, under the impression that they will become incorporated with the new bone or callus, and thus, like splints, give solidity to the union, is unsound both in theory and in practice; no vital union will ever occur. That they may become imbedded in the callus—that is, encysted—is not improbable; I have seen this take place; but they will eventually give trouble, by exciting inflammation, suppuration, and necrosis in the new bone as well as in the soft parts, after the manner of a sequestrum, and will require removal.

Where there is much comminution and the fragments are driven into the cancellated structure, either amputation or excision must be resorted to. When balls are imbedded in bone, their removal is just as important as when in the soft parts. If a portion of the missile projects, it may be seized with the Thomassin forceps and extracted; or it may be dislodged first by a lever (Fig. 173) and then removed by the forceps or scoop. If deeply buried in the bone, the latter should be cut away at one point until the lever can be carried beneath it. It may be necessary to enlarge the opening in the soft parts to effect this. Lastly, it may be extracted by the instrument which combines the screw and forceps.

Fig. 173.



Lever to dislodge a ball from its position.

There is a limit to the search for balls and other foreign bodies: first, in cases where all the ordinary measures have been exhausted without success in trying to ascertain their position; secondly, where they are lodged in such inaccessible localities, as the lungs, brain, and other parts, that the dangers to structure in attempts at removal would be greater than those resulting from the presence of the foreign body itself.

4. *Local and constitutional treatment.*—After the removal of all foreign matters and the shaving of the hair, the wound should be thoroughly cleansed by spraying it with carbolated water and covering with a pledget of lint or paper-mass soaked in the same liquid or in carbolic acid and sweet oil, the dressing being secured by the turns of a roller loosely applied, so as not to confine the discharges. If the wound be in the arm, the limb should be placed in an easy position upon a splint, in order to maintain entire quiet; if in the leg, the patient must be placed in the horizontal position in bed. The treatment of gunshot wounds by irrigation, where there is much laceration of the soft parts, as frequently occurs in the bursting of guns or shells, has yielded such splendid results in my hands that I always resort to it when feasible, using water containing either carbolic acid or permanganate of potash. During an active campaign, when there are many wounded, where the hospital accommodations are only temporary, and the patients are in transition from place to place, it is impossible to carry out the antiseptic treatment with sufficient detail, and therefore the most eligible dressing is plain cold or iced water, with or without the addition of a little laudanum, frequently wetting the pledget in order to keep it cold. Cold water is not a modern dressing: it was used by Larrey, Guthrie, and others. No attempt should be made to close such wounds by strapping or other means; close union is not to be expected. The opening must fill up by granulation; and this will be preceded by inflammatory, suppurative, and sloughing processes,

which demand a free exit for the discharges. In twenty-four hours after a wound has been received, the parts around become a little swollen, less pliable than in health, with a circle of inflammatory redness, and with increased sensibility. A little thin transudation may escape from the orifice made by the bullet. The inflammation results in suppuration in four or five days, by which dead tissue is detached and escapes with the discharge, after which granulations spring up, and the opening closes after an uncertain period of delay. The practice at one time popular with French surgeons, of laying open the entrance and sometimes the whole track of gunshot wounds, with a view to change their character or to convert them into incised wounds, has at present but few advocates. It is useless to close the external orifice by quick union when a process of mortification is going on in the deep parts, the products of which must find a way of escape. When a wound is extensively lacerated and the patient enfeebled by imperfect reaction, the cold water must be used with caution, or the vitality of the parts, already impaired by local and general violence, may be hopelessly destroyed under the depressing influence of cold. The temperature of the water in such cases should be very little below that of the body. As soon as suppuration is established, a tepid liquid should be substituted for a cold one. At this time the parts are to be carefully scrutinized, and if an abscess forms, free incisions should be promptly made; otherwise extensive burrowing of pus will follow. These punctures should be so planned that by their dependent openings a good drainage will be secured. There are sufficient reasons in all such cases to apprehend the diffusion of pus among the components of a part, as the different planes of tissue which serve to limit these products have been opened into one another by the penetration of the projectile. Should the wound prove indolent or the discharges unhealthy, the condition of the sore may be improved by injections of carbolated water, salicylic acid, or very dilute alcohol. When attacked by erysipelas, followed by much tension, free incisions become imperative, in order to unload the subcutaneous tissue and prevent suppuration and sloughing. After this the best application is old linen saturated with carbolated water and laudanum (carbolic acid, one drachm; water, six ounces; laudanum, three drachms). Gunshot wounds usually heal first at the point of exit, the granulations gradually advancing to the opening of entrance, which closes and cicatrizes last. Neudörfer thinks this is due to the changed movement of the ball, by losing its rotary motion as it leaves the part, and producing in consequence a division of the structures similar to that in an incised wound. It is by no means established that such a change of motion occurs; and I incline to the opinion that the difference is to be ascribed to diminished momentum, and a correspondingly less degree of injury to the parts.

The slow progress in healing which so often characterizes this class of wounds tends to impair the nutrition and functions of the limbs. The muscles waste, the joints become stiff, and the tendons move painfully through their sheaths. This should be counteracted by friction with stimulating liniments or alcohol, conjoined with systematic movements. The tendency to contraction of muscles, either from the flexed state of the limbs or from local irritation transmitted along certain nerves, must be carefully watched, and resisted by extension and passive motion, or even by tenotomy where these fail.

After relieving shock and securing reaction, by the means which have been already described, as preliminary to all other treatment it is the duty of the surgeon in severe cases to enforce absolute rest. The bowels should be regulated, opiates administered to relieve pain and procure rest, a nutritious diet and thorough ventilation enforced, and stimulants and tonics administered in cases where there is prolonged suppuration. As many wounded men are brought from miasmatic localities and from overcrowded hospitals, there may be an additional complication in the development of malarial fever or intestinal troubles, such as diarrhœa and dysentery, all of which militate against

the repair of the wounds. In such instances quinine must be given freely, and for the intestinal trouble scruple doses of subnitrate of bismuth, with one-eighth of a grain of morphia, three times a day. In cases where there is relaxation of the bowels, with anæmia, the liquor ferri pernitratis, in doses of eight or ten drops, largely diluted with water, and administered three or four times a day, will have a good effect. If the diarrhœa depends upon ulceration in the lower part of the colon, injections of nitrate of silver will be productive of good. No remedies, however, will avail much without a properly regulated diet; and no other article of nutrition is so useful as milk.

During the last year I was consulted by a physician who had suffered continuously with chronic diarrhœa ever since the close of the late war. He had been a prisoner in the Libby prison, and contracted it at that time. The peculiar pain which he experienced induced me to examine the lower end of the bowel, where I discovered at the verge of the anus a fissure, for which I divided the underlying fibres of the sphincter. The operation cured both the fissure and the diarrhœa.

Secondary hemorrhage.—As secondary hemorrhage is liable to follow gunshot injuries, every precaution should be taken in anticipation of such an event: especially should there be unwearied watchfulness when the region traversed by the ball is in the neighborhood of important vessels. These after-bleedings occur rarely earlier than the seventh or later than the twentieth day, as it is during this period that sloughs are ordinarily detached. Occasionally the hemorrhage may be postponed to a much longer time, so that the vigilance should not be relaxed for several weeks. To be entirely prepared for such an event, a tourniquet should be placed loosely about the part when feasible, and minute instructions given to both nurse and patient as to its proper position and the mode of screwing it down. The localities of the great blood-vessels should be marked at those points where digital pressure can be applied with the best effect, and full directions must be given to the patient to command the orifice of the wound with his finger should bleeding occur.

When hemorrhage does arise, the case has assumed the gravest proportions, and in this event there are three courses left to the surgeon: first, to enlarge the wound, search for the vessel, and tie both of its extremities; second, to tie the main artery in its continuity; and, third, to amputate. If the first course be determined upon,—and in my opinion it should always take the precedence of the other methods,—it should be executed at once, and the ends of the vessel made secure with the animal ligature; after which the limb should be elevated, to diminish the force of the blood-stream in the faulty vessel.

The sloughing condition of the soft parts, and an imperfect thrombus, are the chief factors immediately concerned in determining the hemorrhage; and these depend upon a defective state of the blood and an imperfect nutrition of the tissues about the wound. To correct these constitutional and local defects it is necessary that the patient should have an ample supply of nutritious food, with a proper proportion of sound vegetables. Wine, whisky, or brandy, in moderation, will be indicated, together with quinine, iron, and, not the least important, plenty of fresh air.

The wound should be kept free from all the products of decomposed tissue by being frequently washed with a solution of permanganate of potash and injected with either carbolated water or dilute alcohol (one part of alcohol and eight parts of water).

In addition to these measures, the precautions against another bleeding must be renewed, and nothing left undone in the way of preparation for such an event. Let it be remembered that it is the amount of blood lost on such occasions which often decides the battle for life, and which, too often, induces a fatal pyæmia. Should the hemorrhage be renewed, let the vessel be tied in its continuity with the animal ligature, and the same after-treatment be pursued as in the first instance; should this likewise fail, then let the limb be removed within the limits of sound structure.

Amputation and Excision in Gunshot Wounds.

The damage inflicted by gunshot projectiles will demand in many cases a resort to amputation. It will scarcely be doubted that in the exigencies of military practice many limbs are doomed to the knife, and very properly so, which in civil practice could be saved. I have on several occasions heard the remark made that many limbs had been needlessly sacrificed by surgeons during our late war,—a charge entirely unfounded in fact. Indeed, I am quite satisfied from personal observation that if any error was committed it was in efforts to save limbs, and not in their removal. Amputation in properly selected cases is a most humane procedure; it is not a humiliation or an opprobrium, but a surgical triumph.

The period for amputation.—The time to remove a limb is a question of great moment, and had attracted much discussion from the days of Ambrose Paré until about 1760. Old Richard Wiseman's advice was to amputate quickly.

When Bilguer was appointed Surgeon-in-Chief to the Prussian army, an order was issued directing that no amputation whatever should be done for gunshot injuries,* and of the six thousand wounded Prussians not a limb was cut off. "To cut off a leg," said Bilguer, "after a bad wound is but to add wound to wound; to heap new pain upon a disordered system." What was the result of this insane order? One-half of the cases of gunshot fractures of the extremities died, and of the remaining half, one-third were entirely disqualified for any occupation whatever. This fearful mortality was in striking contrast with the success of Larrey, who saved three-fourths of his cases by primary amputation. There is no necessity at this day to defend the propriety of amputation in gunshot injuries.

There are three periods in which amputation may be done: these are called *primary*, *intermediary*, and *secondary*. The first period is that antecedent to the development of inflammatory fever, and cannot extend over more than thirty-six hours, or forty-eight hours at the farthest. The second period is that of inflammatory or traumatic fever, and varies much in its duration. The third period begins after the subsidence of the second and the establishment of suppuration. These subjects will be again referred to and discussed under the head of general amputations.

Duchenne, in 1625, advised early operations, before the constitution was disturbed by inflammatory symptoms. Richard Wiseman† recognized the importance of immediate or primary amputation after gunshot injuries. Le Dran,‡ in 1737, enforced a similar doctrine, with cogent reasons for his choice. Ranby,§ surgeon to King George II., entertained similar views upon this subject. In 1756 the Royal Academy of Surgery in France made the subject one for a prize essay, which was awarded to Faure. This thesis, though not altogether adverse to primary operations, circumscribed their application to very narrow limits. Boucher, on the other hand, was a strong advocate for early amputations. The testimony of Thompson, Guthrie, and Hennen exhibits the superiority of primary over intermediary and secondary operations in a still stronger light than that of their predecessors. Among English military surgeons, with the exception of Hunter and O'Halloran, there was little diversity of opinion on this subject. Guthrie declared that the question did not admit of dispute; and to the same effect were the declarations of Hennen and Ballingall. Dr. Schrive has shown that during the Crimean War, among the French troops, the success for the most part in primary operations was two-thirds greater than in secondary. The experience of the English did not materially differ in this particular from that of the French. Among the three thousand Russians wounded at the siege of Sebastopol, one-half of the primary amputations proved successful, while

* Ballingall's Military Surgery, p. 368.
† Surgical Treatise, by Richard Wiseman, 1696, 3d London edition.
‡ Treatise on Military Surgery, 1737.
§ On Methods of Healing Gunshot Wounds, 1781.

two-thirds of the secondary ones were fatal. Still later we have the accumulated experience of the Franco-Prussian War and that of our own country, both going to show the soundness of the prevailing doctrine.

In the able analysis given by Dr. Otis,* the surgical historian of the late war, we find 5456 cases of amputation in the continuity of the arm for shot injuries. The ascertained result in 5273 cases was a mean fatality of 23.6 per cent. Of this number there were 3259 primary operations, with 602 deaths, a mortality of 18.4 per cent.; 902 intermediary operations, with 302 deaths, or 33.4 per cent.; and 411 secondary amputations, followed by 114 deaths, or 27.7 per cent.

So decisive are these figures that when a limb is doomed to amputation the only condition justifying delay is shock. Should this last over thirty-six or forty-eight hours, it will be best to wait until the resulting traumatic or inflammatory fever is over and the stage of suppuration established.

Cases demanding amputation after gunshot injury.—In general, when a limb is carried away by a cannon-ball, leaving a tattered, shapeless stump, the case is one demanding amputation, and at a point sufficiently far above the wound to insure sound tissue to cover the extremity. All cases, however, are not so easily solved as this, and I proceed to formulate them as follows:

1. When the principal vessels and nerves remain uninjured, the bones not badly comminuted, and the soft parts not extensively torn, it would be improper to amputate. An immovable dressing, with attention to drainage, will often reward our efforts to save a limb, with excellent recovery.

2. When the bones of a limb are comminuted and the fragments thrust into the surrounding soft parts, these tissues themselves being greatly lacerated, and the principal vessels torn, the removal of the member admits of no question: it should be amputated.

3. An arm or a leg may be crushed by the fall of heavy ordnance, pulpifying the muscles and comminuting the bones, yet the skin exhibit only contusion. When grasped with the fingers it will be found soft and without resistance. Such an injury will be followed by a rapidly spreading mortification: the limb should be removed.

4. When the soft parts of a limb are carried away for a considerable extent down to the bone, dividing the chief vessel, it should be amputated.

5. The mere division of the brachial artery, without any serious damage to the soft parts or bone, is not a sufficient reason for amputation. It is better to secure the vessel at each extremity, and wait to ascertain if the collateral vessels will not preserve the vitality of the arm. Should they prove unequal to the task and signs of mortification develop, the only resort is the knife, which should be applied above the injury.

6. When the wound involves the elbow-joint, excision should be substituted for amputation.

7. When the shoulder-joint is implicated, the head of the humerus being comminuted and the axillary or brachial vessels not divided, excision should be adopted.

In cases where the comminution is not extensive and the bone not splintered, it may answer to pick away the fragments and treat the injury conservatively.

Excision of the head of the humerus.—Larrey may be said to have popularized excision of the shoulder-joint. The labors of Esmarch, founded on the experience of the Schleswig-Holstein War, served to attract further attention to the subject. He records 19 cases of excision of the head of the humerus, 12 of whom recovered with a useful arm, and 7 died. Of the 16 excisions of the head of the humerus performed in the English army of the Crimea,—8 primary and 5 secondary,—there was only a single death. In a collection of 856 cases of the same operation on account of gunshot injuries,† 582 recovered and 267 died,

* Surgical History of the War of the Rebellion, vol. ii.

† Prize Essay on Resections, by Dr. H. Culbertson, Trans. Amer. Med. Assoc., 1876.

leaving 7 cases in which the result was undetermined. Of 951 determined cases of excision of the shoulder-joint, 603 recovered and 348 died; a mortality of 36.6 per cent. The result of operations done at the different periods was ascertained in 831 cases. Of 515 primary excisions, the mortality was 31.06 per cent.; of 224 intermediary operations, the death-rate was 46.4 per cent.; and of 92 secondary operations, 29.3 per cent. Adding together the intermediary and secondary operations, the mortality was 41.4 per cent.* In addition to the above, Dr. Otis has collected 378 cases of excision of the head of the humerus from various sources, with 215 recoveries, 156 deaths, and 7 cases undetermined; a mortality of 42 per cent. The difference in favor of primary excisions, according to this statement, amounts to 10 per cent.; and the fatality of intermediary excisions appears so great that no consideration, save one of extreme necessity, would justify an operation at this period.

Amputation at the shoulder-joint.—The records of the Surgeon-General's Office, as tabulated and analyzed by Dr. Otis, exhibit 827 cases of amputation at the shoulder-joint for shot injuries and diseases consequent upon these. These amputations were distributed as follows: 499 primary, with a death-rate for known cases of 24.1 per cent.; 157 intermediary, with a mortality of 45.8 per cent.; 66 secondary, with a mortality of 28.7 per cent.; and 130 in which the period could not be determined, the mortality being 23.5 per cent. The mean death-rate of the aggregate number of all periods was 28.5 per cent.

Expectant and conservative plans.—It is understood by these terms, as applied to shot injuries of the scapulo-humeral articulation, that the arm was placed at rest, inflammatory symptoms combated, abscesses opened, and fragments of bones removed as they became loose. There are 505 such cases analyzed in the "Surgical History of the War," exhibiting a mortality of 27.5 per cent.

Comparison of methods.—If a comparison be instituted between the different methods of treating shot wounds of the shoulder-joint, it will be seen that the death-rate by excision is 36.6 per cent.; by amputation, 28.5 per cent.; and by expectancy, 27.5 per cent.; a result favorable to the last method. These facts teach the importance of discriminating with the utmost care the cases suited to each method, and show that the mere implication of the shoulder-joint, even though attended with fracture of the head of the humerus, is not sufficient ground for a resort to the radical measure either of excision or of ablation. Excision should be confined to cases attended by great comminution of the head and upper part of the shaft of the humerus, and amputation to cases in which the blood-vessels are severed, or where the soft parts of the shoulder are carried away and the superior extremity of the bone broken into fragments.

Excision in the continuity of the humerus.—In gunshot wounds of the arm, comminuting or splintering the humerus, there are three courses open to the surgeon,—excision, amputation, and conservatism. Aside from experience, there are certain reasons for regarding the operation of primary excision in an unfavorable light. A bone shattered by a conical ball will in most cases undergo, to some extent, necrosis. The tremendous shock transmitted through its structure by such a missile affects its nutrition far beyond the limits of impact and fracture, giving rise often to osteomyelitis and other diseases. These conditions, together with the tedious suppuration which follows, separating extensively the periosteum, tend to defeat bony union. In two instances of gunshot fracture of the humerus which appeared exceptionally favorable for excision, I recently operated without success, both terminating in a false joint.

The experience derived from the Schleswig-Holstein and the Crimean War proved unfavorable to excision in the continuity of the humerus; and the results of similar operations during the late American War are not calculated to commend this procedure, but rather to condemn it. Excision in the continuity of the humerus for shot fractures was done in 696 cases† during the War of

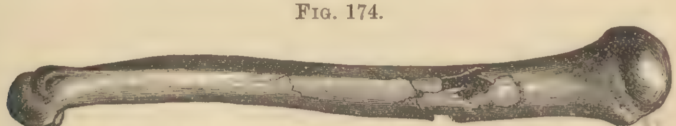
* Otis, Surgical History of the War of the Rebellion, vol. ii. p. 600.
† Ibid., vol. ii. p. 696.

the Rebellion, with 477 recoveries, 191 deaths, and 28 undetermined,—a mortality-rate of 28.5 per cent. A further examination shows that of the number stated to have recovered, 164 cases resulted in non-union, and 37 subsequently required amputation. Of these 696 operations, there were 487 primary, with a mortality of 30.7 per cent.; 93 intermediary, with a mortality of 31.1 per cent.; 41 secondary, with a mortality of 12.1 per cent.; and 75 in which the period could not be ascertained, with a death-rate of 19 per cent. These statements exhibit the superiority of secondary operations over all others.

In 3005 cases of shot fractures treated by expectant and conservative plans, and recorded in the "Surgical History of the War," 451 died and 2509 survived. Of the last number, 1055 were returned to duty, and 1454 discharged. There is, therefore, a mortality-rate of 15.2 per cent. against 28.5 per cent. by excision, or nearly one-half greater by the latter than by the former plan.

Amputation of the arm.—It is difficult to determine in all cases with precision what amount of injury will justify amputation of the arm. When the limb has been swept away above the elbow by a cannon-ball, leaving the parts ragged, a resort to the knife, in order to form a satisfactory stump, admits of no discussion. When the soft parts have been extensively torn away, the bone splintered and greatly comminuted, implicating perhaps the elbow- or shoulder-joint,—and when the brachial artery is divided,—the propriety of amputation can scarcely be doubted. There are, however, other cases of injury to the arm in which the course of the surgeon is not so clearly marked out, and where he will be reduced almost to inaction before the perplexing difficulties which confront him. It may serve to relieve in some degree this state of indecision and distrust of judgment to know that men who have enjoyed the largest experience as military surgeons become more and more conservative in their operations and more disposed to rely on the constitutional resources of their patients. Comminution or splintering of the humerus, when near the middle of the bone (Fig. 174), does not justify amputation. When

FIG. 174.



Comminution of the humerus by a conoidal ball.—Army Medical Museum.

there is extensive shattering near the articular ends of the shaft, the case becomes more grave; but if the blood-vessels and nerves remain sound, and the soft parts be not too extensively torn, excision should be substituted for amputation. Nor does a shot fracture, according to some writers, even though attended with a division of the brachial artery, unless accompanied with other injuries, such as extensive laceration of the soft parts or great comminution of bone, warrant the removal of a limb. In fine, amputation must be a last resort, an extreme measure. It is possible, however, to carry conservatism too far; and I believe that this is the tendency of the military surgery of the present day.

In the "Surgical History of the War"* there is an analysis of 5456 amputations of the arm for shot injuries. The result was ascertained in 5273 cases, showing a mean fatality of 23.6 per cent. Of these operations, 3259 were primary,—done within forty-eight hours,—with 602 deaths, or 18.4 per cent.; 902 intermediary, with 302 deaths, or 34.4 per cent.; and 411 secondary, with 114 deaths, or 27.7 per cent. The mean fatality of all periods was 23.6 per cent. There is also in the same volume an analysis of 2960 cases of gunshot fractures of the humerus treated by expectancy, with 451 deaths, or slightly over one-seventh of the whole number. By a comparison of the two plans, that of amputation and that by expectant and conservative measures, it will be seen that there is the difference between one-fifth and one-seventh in favor

* Surgical History of the War of the Rebellion, vol. ii. p. 805.

of the latter. It must not, however, be overlooked, as Dr. Otis has observed, that in all probability the simplest and most favorable cases were selected for expectant and conservative modes of treatment, and that a large number of cases were excluded in making up the estimate which were, at the commencement, treated conservatively, and afterwards by excision or amputation, in which the mortality-rate was very great. Many of these fatal cases would doubtless have recovered had the latter operations been performed at the outset. I doubt not, from what I observed in the large military hospitals during the war, that if a comparison could be instituted between the radical and conservative methods of treatment, free from all vitiating circumstances, it would be found to be adverse to the latter.

Excision of the elbow-joint.—Excisions of this articulation for shot injuries have been attended with variable success in the hands of different surgeons. In the French armies, according to Chenu, the operation was singularly fatal. During the Franco-German War, out of 212 excisions by the French surgeons, 164 died; a death-rate of 77.3 per cent.* When this is compared with that of the English surgeons during the Crimean War,—seventeen cases recovering in a total of twenty,—and with the results of our own war, it is impossible to avoid the conclusion that there must have been something radically wrong in the management of these cases. There were, during the War of the Rebellion,† 626 excisions of the elbow-joint, partial and complete, of which number 470 recovered, 146 died, and in 10 the terminations were not known; a mean mortality of 23.7 per cent. These operations and their results were distributed as follows: 322 were primary, of which 250 recovered, 68 died, and 4 remained unknown; 197 were intermediary, of which 127 recovered, 69 died, and 1 was undetermined; 54 were secondary, 49 of which recovered, and 5 died; in 53 cases the period was uncertain, 44 of which recovered, 4 died, and 5 remained unknown. The superiority of primary operations over those practiced at a later period is so great that the former are always to be preferred when possible. It will appear from the above statement that excisions of the elbow-joint and amputation in the continuity of the arm during the late war yielded nearly an equal percentage of deaths, the former being 23.7 per cent. and the latter 23.6 per cent. As compared with excisions of the head of the humerus, the mortality being 36.6 per cent., that of the elbow furnishes a lower death-rate. In a grand total of 598 excisions, partial and complete, of the elbow-joint for shot wounds,‡ 479 recovered, 113 died, and 6 remained undetermined.

Amputation at the elbow-joint.—This operation becomes necessary when the forearm has been extensively lacerated and the vessels torn by shot or shell, so that the alternative is offered of disarticulation at the elbow-joint or amputation at the lower third of the arm, a point which yields a less favorable result than when the operation is done higher up. As practiced during the late American War, the operation of amputation at the elbow-joint proved, so far as the limited number of cases show, more favorable than amputation in the continuity of the arm. In 39 cases in which the termination was ascertained, there were only 3 deaths, or 7.6 per cent.§

Amputation in the continuity of the forearm.—The laceration of the soft parts, accompanied with comminution of the bones and division of the radial and ulnar vessels, constitutes a condition demanding amputation. The superiority of primary over other periods of such amputation is well illustrated in the summary given by Dr. Otis, in which the mortality of primary operations is shown to be 9.6 per cent.; that of intermediary, 23.5 per cent.; and that of secondary, 15.7 per cent.

Excision of the bones of the forearm.—Primary excision of these bones is an operation rarely demanded. When the radius or the ulna is splintered or comminuted, the expectant plan of treatment is to be preferred.

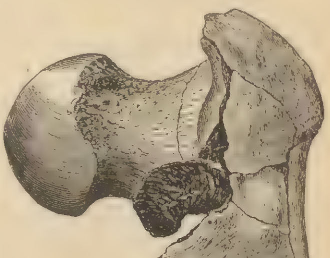
* Surgical History of the War of the Rebellion, vol. ii. p. 901.
† Ibid., vol. ii. p. 894.
‡ Prize Essay on Resections, by Dr. H. Culbertson, Trans. Amer. Med. Assoc., 1876.
§ Surgical History of the War of the Rebellion, vol. ii. p. 909.

Excision of the wrist-joint.—So important is the hand that the surgeon may venture much in attempting its preservation. The operation of excision of the radio-carpal joint was done during the late American War 96 times. In 6 cases the excision was complete, and in the others more or less complete. The number of deaths following these operations was 16, a mortality a trifle greater than in amputations performed for shot injuries of this joint. Unless the disorganization of the articulation produced by a ball is extensive, such cases are best left to a course of expectancy and conservatism; and though the patient will most probably pass through a long period of suppuration, in consequence of caries of some of the components of the articulation, yet ultimate recovery with a stiff joint, after the removal of loose sequestra, is not improbable.

Shot wounds of the hand.—The organization of the hand is so perfect, in consequence of the rich supply and free communication of blood-vessels and nerves, that nothing short of a very complete disorganization will justify its amputation; and when a resort to the knife becomes necessary, it should be confined only to hopelessly-damaged parts.

Gunshot injuries of the thigh.—Shot wounds of the thigh, comminuting and splintering the femur and dividing the femoral artery, will generally demand amputation. The mortality of all gunshot fractures of the thigh, with or without amputation, is very great. According to Macleod, during the Crimean War, among the rank and file only 14 out of 174, and among the officers 5 out of 20, cases of compound fracture of the thigh recovered without amputation. In 96 of the above 174 soldiers amputation was performed, and of the remaining 78, without operation, 64 died. In the cases of the 20 officers, 10 were made the subjects of amputation, and of the remaining 10, not operated on, 5 resulted fatally.* The recoveries of thigh amputation among soldiers during the Crimean War were estimated at 34.7 per cent. That nearly two-thirds of such operations should prove fatal appears almost incredible; and yet, notwithstanding this high death-rate, the fatality was less than that following excision or other conservative plans. As in civil so in military practice, the mortality of thigh amputations increases as the trunk is approached. In the lower third of the femur the recoveries are estimated at 43.3 per cent.; in the middle third, at 40 per cent.; and in the upper third, at 12.9 per cent.

FIG. 175.



Comminuted gunshot fracture of the upper extremity of the femur.—Army Medical Museum.

In instituting a comparison between amputation and other or conservative measures, we have in the surgical history of our own recent war a collection of 2003 gunshot fractures of the thigh,† among which are 82 cases implicating the hip-joint, and 770 in which for the most part the knee-joint was involved. Of those implicating the hip, the mortality-rate after amputation was 100 per cent.;‡ after excision, 83.33 per cent.; and by conservative measures, 100 per cent. By extending the comparison of these three plans to the different portions of the thigh, the result is as follows. In gunshot wounds in the upper third, after amputation, the mortality was 75 per cent.; after excision, 72 per cent.; by conservative measures, 71.81 per cent. In the middle of the thigh, after amputation, the mortality was 54.83 per cent.; after excision, 86.66 per cent.; by conservative means, 55.46 per cent. In the lower third, after amputation, the death-rate was 46.09 per cent.; after excision, 50

* Holmes's Surgery, vol. ii. p. 223.
† Circular No. VI., Surgeon-General's Office, p. 31.
‡ Only two cases were the subjects of amputation.

per cent.; and by conservative measures, 57.79 per cent. In those shot injuries of the thigh involving the knee-joint, with or without fracture, the mortality after amputation was 72.23 per cent.; after excision, 90 per cent.; and by conservative plans, 83.76 per cent. In a comparison of 822 cases treated by amputation with 1117 cases treated by conservative measures, there is 8 per cent. in favor of the former, and this holds good in each region except the upper third, a fact which would suggest the propriety of practicing conservatism in this particular part.

Gunshot fractures involving the head and neck of the femur.—These fractures are injuries of the most serious character. (Fig. 175.) There were no successful cases of amputation at the hip-joint for such wounds in the English or French army. Langenbeck had one successful case in seven operations. All primary operations of this kind during the Italian War died. During our own war the result was different.

How to deal with these fractures involving the superior articulating extremity of the femur can only be determined by a careful analysis of recorded cases with their peculiarities. The following tables* exhibit a comparison between excision and amputation in shot fracture of the upper extremity of the femur:

Excision.

	No.	Died.	Recovered.	Death-rate.
Primary	39	36	3	92.3
Intermediary	33	30	3	90.9
Secondary	13	11	2	84.6
Total	85	77	8	90.6

Amputation.

	No.	Died.	Recovered.	Doubtful.	Death-rate.
Primary	79	75	1	3	98.68
Intermediary	76	70	6	...	92.10
Secondary	20	13	7	...	65.00
Reamputation	8	4	4	...	50.00
Total	183	162	18	3	90.00

In deciding between amputation and excision, the choice must be determined by the character of the injury. The conclusions drawn from the records of the Surgeon-General's Office are as follows. Amputation will be proper—1, when the thigh is torn off, or the upper part of the femur comminuted, with great laceration of the soft parts; 2, when a fracture of the head, neck, and trochanters of the femur is complicated with a wound of the femoral vessels; 3, when a gunshot fracture involving the hip-joint is complicated by a severe compound fracture of the limb lower down, or by a wound of the knee-joint. There are two other conditions mentioned by Dr. Otis which theoretically demand primary or early intermediary amputation, though experience is yet wanting to give them true practical value: 1, where, without any fracture, the vessels are cut off close to the pelvis; 2, where a fracture in the region of the trochanters is complicated with such a degree of longitudinal fissuring as will render excision improper.

Primary excision of the hip-joint is demanded in all uncomplicated cases of gunshot fractures of the head or upper extremity of the femur; intermediary excisions when an early diagnosis has not been made, and in cases of gunshot fractures of the trochanters followed by inflammation of the joint.

* Circular No. II., Surgeon-General's Office, pp. 112, 137.

Secondary excision becomes proper in caries of the head of the femur, whether it be the result of direct injury or of extension of disease from fractures below or about the trochanters, or of damage to the soft parts. The expectant treatment is almost always fatal. These views do not correspond with those of Legouest or Larrey, who thought that amputation should be confined to cases of fracture associated with wounds of the femoral vessels, and even then should always be secondary.

FIG. 176.

Knee-joint comminuted by a ball which is buried in the head of the tibia.—Army Medical Museum.

Dr. Culbertson, in his Prize Essay,* has collected from various sources 121 cases of excisions of the hip-joint for gunshot wounds, with a mortality of 89.07 per cent.

Gunshot wounds of the knee-joint.—These are injuries of the gravest import. When a ball traverses this articulation, injuring the condyles of the femur or the head of the tibia, or both (Fig. 176), and lacerating the ligaments and other soft parts, or when the joint is completely disorganized by the bursting of a shell (Fig. 177), the shock imparted to the system is sometimes so great as to border on collapse. Just how to deal with gunshot wounds of the knee-articulation is an unsettled subject. There are four plans open to our choice: excision, amputation at the joint, amputation at the lower third of the thigh, and immobilization. Excision has been most discouraging in its results. There were no successful cases of such an operation during the Schleswig-Holstein War, nor during that in the Crimea. Of eight cases operated on by Neudörfer in the Austrian army, during the Italian War in 1859, three recoveries are reported. During the late War of the Rebellion eleven cases of excision of the knee-joint were reported, with only one recovery. Langenbeck, however, entertains a more favorable view of conservative measures than either American or British surgeons. In the Bohemian War of 1866, according to his statement, eleven cases of gunshot wounds of the knee-joint were saved out of eighteen. In the Prize Essay by Dr. Culbertson, already referred to, sixty-one excisions of this articulation for gunshot injuries are recorded, out of which number fifteen recovered, forty-five died, and the result in one case was unknown. Langenbeck resorts to amputation or to excision only when the broken fragments at the articular ends of the femur or tibia are entirely detached, or where, in addition to comminution, there is extensive laceration of the soft tissues about the joint. Other cases are treated by immobilization and by antiseptics.

FIG. 177.

Knee-joint destroyed by a shell explosion.—Army Medical Museum.

Taking into view all the facts which we possess in reference to the various methods of managing gun-shot injuries of the knee-articulation, the choice lies between amputation and the use of expectant or conservative measures. When the latter method is adopted, it should always be in connection with immobilization and antiseptic plans of treatment.

* Resection of Joints. Trans. Amer. Med. Assoc., 1876.

Amputation at the knee-joint.—In cases where the femur remains uninjured and the tibia is shattered so near its tuberosity as not to admit of the removal of the limb below this point, amputation through the knee-joint is to be adopted in preference to that in the lower third of the thigh. It is difficult to understand why this operation should have been so unsuccessful with the French surgeons in the Crimea,—only six being saved out of sixty-nine such amputations,—while with American surgeons there were fifty-two recoveries in one hundred and thirty-two operations. Those which were done during the primary period furnished a death-rate of 36.7 per cent.,—that is, in forty-nine operations thirty-one recovered, a mortality much below that following amputation at the lower third of the thigh.

Excision of the ankle-joint for gunshot wounds.—The excisions practiced on this joint have been exceedingly discouraging in their results. We are told by Holmes that during the Crimean War there were no cases of excision of this articulation by either the English or French surgeons. The operation was done by American surgeons during the last war eight times, with five deaths. During the German-Danish War, 1860, Langenbeck excised the joint eight times, with one death. There were two elements in Langenbeck's cases which must be taken into the account,—that of subperiosteal resection and complete immobilization,—neither of which, either in the knee or ankle, was adopted by our surgeons. The free use of the gouge to remove damaged bone after such injuries is regarded with favor by many. Of forty-five cases collected by Dr. Culbertson in which excision was performed, thirty-two recovered and twelve died. Amputation either through the joint, or above in the continuity of the limb, is a much more successful operation than excision, which fact of itself should determine our course where the articulating extremities of the bones are comminuted.

Excisions in the continuity of the bones of the leg.—These operations are very limited in their application. The cases in the following table* are too limited in number to warrant a dogmatic conclusion, and therefore possess only an approximate value in enabling us to form an opinion upon the subjects which they illustrate.

	Died.	Recovered.	Amputation after.	Results not determined.	Total.	Death-rate.
Femur	32	6	...	24	62	84.21
Tibia	11	48	5	20	84	18.64
Fibula	15	60	3	15	93	20.00
Tibia and fibula	1	4	1	2	8	25.00
Metatarsal	5	26	...	2	33	19.23
Total	64	144	9	63	280	....

The figures exhibit a death-rate for the femur which should exclude it from the list of bones warranting excision for shot wounds. The tibia, fibula, and metatarsal bones furnish a favorable percentage of recoveries, but the usefulness of the limb is not ascertained, a condition essential to a proper estimate of the value of an operation.

Sabre Wounds.—Such wounds are inflicted when combatants are engaged in hand-to-hand conflict, and are generally received on the face, head, or over the scapula. The treatment of such injuries does not differ from that proper to incised wounds, and consists in arresting hemorrhage, cleansing the parts, and uniting the flaps by sutures and adhesive plasters. The best local application is water or the antiseptic dressing, and, when conjoined with rest, will usually limit inflammation and suppuration.

* Circular No. VI., Surgeon-General's Office, U.S.A., p. 76.

CHAPTER III.

INJURIES OF THE HEAD.

GENERAL CONSIDERATIONS.

THE important office of protecting an enormous nerve-centre, subservient to intellection, sensation, and motion, devolves upon the head; and while each component is admirably adapted to answer a special purpose, there is a remarkable conspiration in all towards a general object, viz., the defense of the brain. The mechanism of the head is admirably designed to neutralize the effect of external violence. The hair which covers the scalp, the adipose cells which lie closely compacted together in the connective tissue, and the stratification and mobility of its components, all tend to break or diminish the intensity of blows. The form, also, of the skull is that best suited to decompose force. It is not a plain hollow sphere, fashioned out of a single piece, but consists of numerous separate pieces, and these are united, not by tongue and groove, nor by overlapping, except in a very limited degree, but by serrations. Nor are the different pieces of uniform density in their entire thickness, each of the three tables possessing a peculiar arrangement of its particles most favorable to the neutralization of force; and lastly, as an additional means of protection, the skull has an articulation with the spine which admits of great freedom of movement in different directions, thus allowing it to recede from blows and elude serious damage.

Injuries of the Scalp.

Wounds of the cranial coverings may consist in contusions, incisions, lacerations, and punctures.

Surgical anatomy of the scalp.—A brief description of the components of the scalp and their arrangement will aid materially in the study of its injuries.

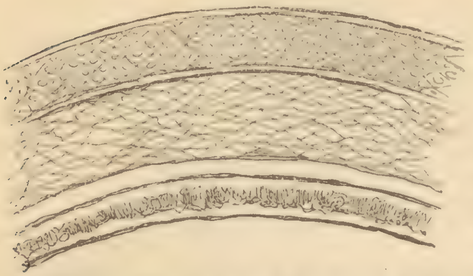
The order of tissue-planes is—skin, superficial fascia, occipito-frontal muscles with their aponeuroses, and sub-aponeurotic connective tissue.

The skin is secured very closely to the occipito-frontal aponeurosis by an intermediate cellulo-adipose structure, consisting of perpendicular and oblique connective-tissue fibres, possessing but little elasticity and containing small, shot-like masses of fat. In this tissue or fascia are situated many sebaceous glands, and in it run numerous blood-vessels and nerves. The arteries are derived from the temporal, occipital, auricular, supra-orbital, and frontal. The nerves are from the fifth and seventh pairs, the occipital from the superficial cervical plexus, and the occipital from the second and third cervical nerves. The occipito-frontal muscles underlying the superficial fascia are digastric in form, having fleshy portions in front and behind, with an intermediate tendon, which is usually called the aponeurosis. This structure is penetrated by vessels, branches of those already described, which in this way reach the pericranium. Between the aponeurosis and the pericranium is another fascia, consisting of delicate, elastic connective-tissue fibres, entirely free from all fat, and usually containing much serous moisture. The different strata of the tissues of the scalp are shown in Fig. 178.

Contusions.—Contusions of the scalp are quite common both in children

and in adults. A child falls against the corner of a table or stool or upon the floor; an adult receives a blow with a bludgeon or is thrown from a vehicle against a curbstone, and in a few seconds a swelling or bump makes its appearance. This swelling is due to the extravasation of blood and serum, and possesses certain peculiarities of form which serve to distinguish it from all other swellings in the region. It is sharply defined, terminating abruptly within moderate limits, and not insensibly blending with, or fading into, the surrounding parts. It is also depressed in the centre, and conveys, to one not familiar with such appearances, the idea of a depression in the skull. If, moreover, a finger be forced firmly against the bottom of this sunken spot, an increased indentation will be made, which would not be consistent with the supposition of a depressed fracture. The explanation of such appearances will be found in the anatomy of the superficial fascia. The force concentrated on a point of the scalp depresses the skin and displaces the fat, forcing it into the meshes of the surrounding connective tissue so as to form a compact wall on all sides, the skin remaining depressed, from the absence of elasticity in the subcutaneous fascia. A swelling, technically termed *caput succedaneum*, is frequently seen in the scalp of new-born children, in cases where the labor has been tedious and the head long delayed in the pelvis. These are sometimes described as being underneath the aponeurosis; and though such is sometimes the case, they are oftener in the superficial fascia. The blood which they contain does not coagulate, but remains liquid. These blood-swellings sometimes provoke suppuration, and are converted into abscesses. When diffuse accumulations, either of blood or of pus, follow injuries to the scalp, they are below the aponeurosis, and therefore can readily extend through the loose sub-aponeurotic fascia.

FIG. 178.



Diagrammatic view of the layers of the scalp and skull: *a*, the skin; *b*, the occipito-frontal muscle and aponeurosis; *c*, the superficial fascia; *d*, the pericranium; *e*, the sub-aponeuretic connective tissue; *f*, the cranial bone, consisting of an internal and an external table, with an intermediate porous or diploic structure.

TREATMENT.—The treatment of such contusions consists in the application of cold-water compresses; or, if the swelling is disposed to linger, of pledgets wet with a solution of muriate of ammonia, alcohol, or tincture of arnica. These failing, the swelling should be brushed over with tincture of iodine, and a moderate amount of compression applied. No operative interference is allowable, save when the tissues degenerate into an abscess, in which event, whether in the superficial fascia or beneath the aponeurosis, it is proper to lay it open by a free incision and afterwards treat it antiseptically. In every case which I have seen where the tumor had been thoughtlessly opened, there followed a tedious suppurating sore. In one instance, a blood-swelling was opened by the medical attendant, and, in defiance of all treatment, refused to heal. On opening it freely, a small tent, which had been used to keep the puncture from closing, was found inside, the removal of which was followed by a cure.

Wounds.—Open wounds of the scalp may partake of the character of incised, lacerated, or punctured wounds, though generally they are lacerated; when not extending below the aponeurosis, there is little separation of the flaps, but when below this the detachment may be great. In transverse wounds over the forehead the retraction is greatest, particularly if deep enough to divide the underlying muscle. A brick falls from a scaffold or building upon the head, the edge of which makes a lacerated wound: a carter is thrown from his wagon, his head striking against the curbing of the street, or the wheel of a wagon grazes the scalp: if in any of these cases

the wound extends deeper than the aponeurosis, a large flap may be torn away from the pericranium, as the connection between the two is very slight. Some years ago, I was called to see, with Dr. Jones, of this city, the case of a woman who, while engaged in the manufacture of macaroni, had her hair caught in a revolving shaft, by which the entire scalp was torn away from the cranium. Though accurately replaced and sutured, it failed to unite, and was followed by general exfoliation of the cranial bones, after which the head was covered by an extensive cicatrix.

A curious case of extensive separation of the scalp is related by Dr. Paul Eve.* An ignorant midwife, mistaking the protruding scalp of a fœtus for the bag of waters, made a deep gash in it with a pair of scissors. The wound extended below the aponeurosis, and when the labor-pains increased, the head was extruded through the rent in the scalp, the latter being everted and turned down over the face and neck very much as one would peel the skin from an orange.

Treatment.—In all large wounds of the scalp the hair should be cleanly shaved for a short distance around the seat of injury. All foreign matter, such as dirt, or particles of sand or glass, should be carefully washed away or extracted, and the hemorrhage arrested. In wounds of this region the bleeding is usually quite profuse for a short time, but rarely so persistent as to require the ligature, being generally controlled by a wet compress and roller. When over the temple or occiput or behind the ear, the ligature will sometimes be necessary, as the temporal, occipital, and posterior auricular arteries are quite large in these localities. In sloughing of the scalp, troublesome hemorrhage may follow, and in such cases the plan of Hewett should be adopted, that of pressing over each main trunk until the one at fault is found, and then controlling its circulation, either by a compress and roller, or by tying. It is more difficult to secure vessels in the scalp than elsewhere, as they retract within the dense unyielding structure. It is always proper, however extensive the detachment of the flap may be, to replace it *in situ*. Irregularities or ragged points should not be cut away, unless hanging by a slender thread of tissue. The vascularity of the scalp is so great that the vitality will be retained in fragments which have but a very limited connection with the flap. Foreign matters being removed, the bleeding arrested, and the parts well sponged with carbolated water, the closure of the wound becomes the next duty. This may be accomplished by adhesive strips, by separating two or three hairs on each side of the wound and passing them through a perforated shot, or by the metallic suture. There is a popular notion that sutures should not be introduced into the scalp, under the supposition that they tend to excite erysipelas. I believe that this fear is without foundation, and have, therefore, no hesitation in advising their use when deemed necessary. Where there is any loss of substance it will be improper to attempt apposition by making tension. The structures, being without elasticity, will not tolerate such traction; the suture will quickly cut out, and the tension may provoke an inflammatory attack.

Suppuration may follow contusions and wounds. If in the superficial fascia, abscesses are circumscribed, and heal kindly after being opened. When an abscess is formed in the sub-aponeurotic tissue, it will be diffused, and should be opened freely at a dependent point, so as to drain away the pus. Unless early recognized and evacuated, sloughing of the scalp is likely to follow; the pericranium will become detached, and not only so, but the dura mater may be similarly loosened from the inner surface of the cranium, and the bone, thus deprived of its vascular supply, die. In all cases where the scalp is extensively separated from the pericranium, the latter is prone to become detached. Persons who have been scalped by the Indians often suffer from exfoliation of bone from this cause. It does not follow that in every case of pericranial separation the bone will die. On the contrary, I have seen fully two square inches of the frontal bone denuded from the

* Remarkable Cases, by Paul Eve.

effects of a burn, and frequently a less surface from other causes, and yet granulation-tissue cover it over, form a new periosteum, and cicatrize soundly. A surgeon in the early frontier wars with the Indians recommended, in cases where the bone becomes uncovered after scalping, to drill a few openings through the external table into the diploë, in order to invite granulation from the latter. I had occasion once to practice the suggestion on a lad who had a portion of one of the parietal bones exposed from a severe injury of the head. Little red points made their appearance through the openings, but the ultimate destiny of these granulations, and their influence on the exposed table, were rendered negative by the sudden death of the patient from convulsions.

Gunshot wounds of the scalp.—These are made by spent balls or balls and fragments of shells in which the impact is at an angle more or less obtuse. The missile may cut a groove through the scalp, or may travel between it and the bones. It is rare in such cases for the bones to escape being bruised. Such wounds are lacerated, and when produced by pieces of shell are attended frequently with loss of substance.

TREATMENT.—The treatment consists in removing the ball if it has not passed out. To effect this a counter-opening will be required over the spot where the projectile can be felt under the integument. After this the parts should be shaved, and a water-dressing applied, followed by rest, attention to the bowels, and an unstimulating diet.

COMPLICATIONS.—The complications which follow wounds of the scalp, from whatever cause, are more important than the simple injury done to the soft parts. Erysipelas, neuralgia, headache, convulsions, and intracranial suppuration comprise the most common of these sequels. In the War of the Rebellion, wounds of the scalp were very common. Including incised, punctured, and lacerated, we have recorded 669 cases, with 9 deaths and 11 disabled. Of gunshot wounds, there were 7739, with 162 deaths, or a mortality of two per cent., mostly from encephalitis. In the Crimean War, Macleod records 630 cases, with 8 deaths, a mortality of one per cent.

Erysipelas may attack the scalp either from atmospheric conditions or constitutional impairment. Though frequently encountering the disease in the head and face in the idiopathic form, I rarely meet it as a result of traumatism. It may be confined to the skin, or it may involve the connective tissue under the aponeurosis. This last variety is attended with great danger. The disease begins with a slight swelling and redness at the border of the wound, spreads over the head, and may extend to the face. If the sub-aponeurotic cellular tissue participates in the disease, the scalp becomes puffy and œdematous, assumes a dusky-red color, and is attended with great swelling. The head appears almost double its size, and, should the disease extend to the face, the eyelids become swollen, and also the nose and lips, producing such a complete change in the expression and appearance of the face that it is often impossible to recognize the features, however familiar they may have been before. The disease is attended with well-marked constitutional disturbance, often inaugurated with a chill, headache, loss of appetite, coated tongue, frequent pulse, and delirium.

The treatment must be regulated by the form of the disease, the habits and constitution of the patient. If confined to the skin, in which case there will be redness and puffiness but not much swelling, the hair should be removed and the parts covered with lead-water and laudanum, or iodine may be painted on the skin thickly, just beyond the limits of the disease, hoping thereby to arrest its extension. The use of a mixture of tincture of chloride of iron and quinine, applied with a brush over the affected surface, has been strongly recommended by Garretson. I am still undecided as to the value of local applications, and, while it is quite proper to resort to such in order to preserve the *morale* of the patient, I doubt very much if they exercise any very curative influence over the inflammatory action. Should the deep structures be invaded, and the patient suffer from severe headache, it will be proper in an

individual possessed of a strong, vigorous constitution, with a full and resisting pulse, to resort to general blood-letting, carefully watching the effect. As soon as the pain in the head is relieved and the pulse reduced in force and frequency, the flow should be stopped. If, on the other hand, the patient is weak, of a feeble constitution, or of intemperate habits, the lancet will do harm, and should never be used. In such cases our attention must be given, mainly, to the support of the body, administering freely beef essence, plain milk, and milk-punch, with tincture of chloride of iron and quinia: if the patient becomes very restless, opium may be given with advantage. The tendency to abscess must be kept prominently in view. To avoid purulent collections, the wound should be laid open; and if the tension becomes great, a few free incisions from one to two inches in length must be made, so planned as to avoid any of the large vessels of the scalp. After these precautions have been observed, a tepid laudanum and lead-water dressing should be applied over the parts. Not every case demands incisions, nor should they be made unless we have good reason to believe that suppuration is imminent.

Neuralgia and epilepsy are not uncommon sequences of scalp wounds. The cicatrix in such diseases will be found to be supersensitive, and the proper treatment is the excision of the scar. Hodge met with a case of epilepsy from this cause, which was permanently cured by cutting out the sensitive cicatrix.

Injuries of the Bones of the Cranium.

The bones may be contused or broken.

Contusions are produced in a variety of ways, as by balls which have not sufficient momentum to penetrate the substance of the bone, or by brickbats, stones, or bludgeons. Cases of severe contusion are frequently associated with an open wound of the scalp, and sometimes with fracture of the skull, as well as damage to the cranial contents. If the pericranium is bruised, it may result in its separation and in a slight exfoliation of bone from the external plate. If the violence reaches to the diploë, disturbing the blood-vessel system of that structure, which I regard as the source of nutrition to the entire bone, it is liable to be followed by inflammation of one or both tables. When inflammation, either acute or chronic, commences in the diploë, it should be regarded as a dangerous occurrence, as the disease tends to transcend the limits of the bone and to separate the pericranium from the external and the dura mater from the inner table. The separation of the bone from its outer and inner periosteal membranes, as well as its final death, is due to the inflammatory transudation so compressing the vessels as to cut off or embarrass the necessary supply of blood. Nor does the danger end here: an abscess under the dura mater will often provoke inflammation and suppuration in the other membranes of the brain, and in the brain itself. There is also here, as in disease of the cancellated tissue of other bones, a liability to blood-infection or pyæmia, from the introduction of purulent matter into the large veins which exist in the diploic structure. Other changes than those enumerated may follow cranial contusion.

1. *Exostosis.*—An inflammatory deposit from the vessels of the pericranium is sometimes, through the deposition of lime salts, converted into an exostosis or bony tumor.

2. *Hypertrophy.*—Shortly after a contusion, thickening may commence and extend over much of the superior part of the skull. I had in my possession, until within a short period, the skull of an individual who had been struck on the back of the head by a slung-shot. A year or more after the receipt of the injury, though a married man, he became addicted to masturbation. The irritation of the sexual organs became so great that he had to be placed under restraint, having lost every instinct of decency. He finally died in the Philadelphia Almshouse, but from what cause I could not ascertain. On examining the skull, the traces of the old contusion were quite visible

below and to the right of the protuberance of the occipital bone, with marked increase in the thickness of its internal table. The cause of his perverted and uncontrollable habits was doubtless cerebellar irritation from this hypertrophy.

3. *Atrophy.*—Sometimes, after a severe blow upon the skull, a change takes place in the nutrition of the damaged part, by which it is much diminished in thickness. This change is effected by interstitial absorption, similar to that which occasionally affects the neck of the femur after falls upon the trochanter.

Both hypertrophy and atrophy of the cranial bones have their counterparts in those changes following contusions of the soft tissues. A bruise about a joint is often succeeded by a permanent thickening of its structure, and a blow over the shoulder results in wasting of the deltoid muscle.

4. *Caries and necrosis.*—Contusions may end in caries or necrosis, affecting one or both tables of a single bone, or extending over the entire vault. The case of Saviard, related in the "Records of Obstetrical Surgery" for 1762, is the most remarkable instance of cranial necrosis, the entire calvaria having been lost after a contusion of the head. It has been thought that such extensive destruction of the bones of the cranium must be due to some predisposing constitutional state, such as syphilis. This may in some instances be true; but I have seen a number of very extensive exfoliations of the external table, and in one instance of the outer table of the entire calvaria, where no such pre-existing condition could be reasonably inferred.

Symptoms of inflammation in the cranial bones.—It is not probable that any symptoms indicative of the disease will be recognized until some time after the injury has been received. Indeed, a patient may, after an accident to the head, be able to follow his occupation, with perhaps no other discomfort than a dull though constant headache. After two or more weeks this pain will increase in severity, the circulation become accelerated, and the patient complain of slight vertigo, some muscular feebleness, or perhaps rigidity of the muscles in the back of the neck. These symptoms will be followed by wakefulness, or by a troubled, broken sleep, twitchings of the muscles, convulsions (sometimes of an epileptiform character), paralysis, stupor, and death. A lad, twelve years old, under my care in the Pennsylvania Hospital, was admitted for a severe contusion of the head. A portion of the external table of the frontal bone became necrosed. He suffered no pain nor any constitutional disturbance whatever. At the end of six weeks, without any premonitory symptoms, he fell down in a convulsion and expired. In this case the disease of the bone had excited inflammation of the arachnoid, which was followed by a collection of pus over the tentorium. When suppuration takes place in the diploë, or pyæmia follows the disease, it is announced by rigors, elevation of temperature, and sweatings. When suppuration exists between the inner table of the skull and the dura mater, it is sometimes indicated by the existence of what Percival Pott called a "*puffy tumor*" in the scalp, over the seat of abscess. This sign is not always present in intracranial suppuration, and may exist when the latter is not present, as, for example, just before the separation of the pericranium which follows a bruise, or where a serous effusion or pus exists beneath its structure. Indeed, little value is attached to this swelling as pathognomonic of internal abscess. The most characteristic signs of such suppuration are headache, rigors, fever, coma, and hemiplegia.

Treatment.—Inflammation once established in the walls of the cranium is a very unmanageable disease. If limited to the external table, exfoliation will follow in due time. The dead bone should be removed as soon as it is discovered to be movable, and not before; and, until this takes place, the case may be left with great propriety to natural processes. When the diploic structure is inflamed, though we cannot arrest its progress or secure resolution, we may limit or prevent intracranial disease, and for this purpose the head should be cleanly shaved, the patient moderately purged, blood locally abstracted.

cold applied, small doses of a mercurial administered, and absolute rest in the recumbent position enforced.

The sequels of bone contusion should command the greatest attention. If the bruise is superficial, producing a plastic subpericranial transudation, an exostosis may follow. It is only when this outgrowth steadily increases in size that any operative interference is admissible. I have frequently seen such tumors after a short time cease to grow, and remain entirely quiescent. If this result should not be realized after three or four months, the mass should be removed by bone-forceps, chisel, or saw.

For hypertrophy or atrophy we have no remedies, except when they are due to a constitutional taint, which will be considered elsewhere. A question, as to the use of the trephine, arises in connection with intracranial suppuration, and is one of no small interest: Shall a way be opened for the escape of pus? Pott performed the operation in eight cases, with five successes. Dupuytren, in one instance, opened an abscess successfully which was beneath the membranes, one inch deep, in the substance of the brain; Guthrie, one in the arachnoid, which was circumscribed; and Roux, as given by Hewett, one, probably in the brain. Noyes,* of New York, emptied a collection of pus beneath the dura mater, under circumstances not unlike those of Roux's case, the suppuration having followed a diseased bone in which a sinus existed. The closure of this sinus, in Noyes's case, was followed by epileptic convulsions, due to brain-pressure from the accumulation of pus, and for which the trephine was used. The epilepsy was not cured, though relieved. This patient died, three years after, from cerebritis. Jones and Chinault,† of Richmond, Kentucky, trephined the skull and evacuated an abscess, with blood, under the dura mater, forty-two days after a fracture. The patient made a good recovery. Detmold‡ has even carried his puncture into the lateral ventricle, to reach a collection of pus. The patient did not survive the operation. There are several difficulties which environ this subject. *First.* Even where the symptoms following a contusion of the head, such as rigors, delirium, stupor, and hemiplegia, indicate the existence of suppuration, its exact locality is a matter of great uncertainty. It may be below the dura mater, below all the membranes of the brain, in the brain itself, or remote from the seat of cranial injury. Holmes and Bell each opened the cranium in a case where the symptoms of cerebral pressure were well marked, but no pus was found. In the case which I have given of the boy dying of abscess, in the Pennsylvania Hospital, following injury of the frontal bone, the pus was situated on the tentorium. *Second.* The suppuration is often diffused, the result of an equally wide-spread meningitis. *Third.* The symptoms on which the operation is based are often due to pyæmia, in which the general system is hopelessly involved, abscesses existing in the lungs, liver, sinuses of the brain, and other parts of the body. Hewett gives eight cases of trephining for abscess at St. George's Hospital, all of which proved fatal from pyæmic and structural changes of different kinds in and below the arachnoid. In one case, in which I punctured the protruding dura mater and gave exit to the accumulation, the patient subsequently died from pyæmia.

It will be found that the successful cases of trephining for abscess have been, for the most part, those where the pus was beneath the bone and external to the dura mater, or where either a fracture or a sinus led to the exact locality, or where the pus was circumscribed. Of the seventeen cases mentioned by Holmes which were left without operation at St. George's Hospital, all died. With such an alternative, therefore, I shall always feel it my duty, where there are good grounds for believing in the existence of suppuration and with a reasonable conviction of its locality, to open the skull and give to my patient the only chance, desperate as it is, which remains for his rescue. The most favorable cases for operation are those in which hemiplegia exists, as it indicates a circumscribed collection; though in a case recorded by Guth-

* Hamilton's Surgery, page 533. † Ibid., page 533.
‡ American Journal of the Medical Sciences.

rie in which paralysis was present, no collection was found on opening the skull. The existence of pyæmia is decidedly unfavorable to an operation, as, even should we be fortunate enough to reach the collection of pus, its evacuation would not correct the constitutional infection.

As to the proper place in which to apply the trephine, the judgment of the surgeon must determine the position, after a careful and comprehensive consideration of the case. Should the "puffy tumor" of Pott be present, it must not be under-estimated, and the incision should be made directly through this swelling, to the bone. Where the scalp is detached and can be raised up from the outer table, the trephine should be applied at that point, and if, underneath, the bone is of a dull-gray color, the indications are still more definite. When the diploë is reached, should pus make its appearance, it is deemed an unfavorable sign, as the case is probably one of pyæmia, whatever else may exist. After the ring of bone is excised, should no pus be found external to the dura mater, the latter should be carefully examined, in order to ascertain whether a purulent collection exists beneath. This will be indicated by a tendency in the dura mater to rise up or protrude into the opening made in the bone; and if such be the case, the membranes should be punctured with a sharp-pointed bistoury. If no pus is encountered in this position, and yet there is reason to believe that it is in the brain-substance, what course is next indicated? Shall an opening be made into the brain at a venture, or shall the surgeon be content to wait for instructions by the future progress of the case? There are reasons for both courses. Roux* once trephined for abscess, and, not finding any collection after opening the membranes, proceeded no further. The patient died, after which an abscess was found almost at the surface of the brain. Petit trephined a child, after a compound fracture, without obtaining any pus and without any alteration of the urgent symptoms, though some bloody serum escaped. Two days after, an abscess found its way spontaneously to the opening and discharged, after which the boy recovered. In a very remarkable case,* in which a knife-blade was driven through and broken off in the skull, and which had remained several years without causing any unusual symptoms, but finally gave trouble, Dupuytren trephined the head, removing the foreign body, and afterwards cut into the brain, emptying a large collection of matter, and thereby saving the life of his patient. We need not err in either direction in cases of such obscurity. The exploring-needle should be introduced into any suspicious locality, and if this invaluable instrument discloses a purulent collection, the bistoury must open the way for its escape; if not, all incisions are rash and unsurgical.

If the operator, with all these precautions, fails to find the abscess, what next? Unless some new development shall have occurred, which will render a second perforation more promising than the first, there is no indication for its repetition. There can be no justification for boring holes around the entire head or at several different points (as one would prospect for oil), after the recommendation of Heister and Benjamin Bell.

Fractures of the Skull. ANATOMICAL CONSIDERATIONS.—The mechanism of the head, when properly understood, will explain very satisfactorily the effects of external violence. Its spherical form serves not only to decompose forces when applied to its surface, their vibrations radiating in all directions from the point of contact, but also, by conducting these vibrations to the base, often determines fractures in this locality. The structure of the bones, consisting of two tables of different degrees of density, with an intermediate spongy or diploic tissue, explains such facts as the following: the external plate may be broken without injury to the internal; the internal may be fissured without fracture of the external; there may be fracture of the external table, with depression, without encroaching upon the brain, the bone being driven into the diploic structure.

* Archives Générales, vol. xxiv, page 81.

When the calvaria is removed, three distinct fossæ are seen occupying the inner surface of the base, the posterior one called the cerebellar fossa, and the anterior two the cerebral fossæ. These rise, as we advance from behind forwards, in planes or terraces, one above the level of the other. Notwithstanding the great expanse of bone forming the superior portion or vault of the cranium, it is contracted at its base into three comparatively very narrow cavities. The orbital plates of the frontal bone form the floor of the anterior fossa, the petrous parts of the temporal bones separate the middle from the posterior, and the basilar process of the occipital bone forms not only a portion of the posterior but rests against both the body of the sphenoid and the margins of the petrous portions of the temporal bones. It also constitutes the bony roof of the pharynx: hence the hemorrhage into the throat when it is broken. The petrous parts of the temporal bones lodge the organs of hearing, which explains the bleeding from the ears and the oozing of the cerebro-spinal fluid when these bones are fractured. It follows from these anatomical peculiarities that there are three basal foci, towards which all violent forces concentrate. It is also true that such forces take the shortest or most direct route to the base.

In applying physical laws to the mechanism of the skull, we have the explanation of the fact that a blow over the frontal region, should it be forcible enough to reach the base, will fracture the orbital plate, or plates, of the frontal bone which form the floor of the anterior cerebral fossa. By the same law, a force applied upon the vertex will reach the middle fossa, and as the petrous parts of the temporal bone are the foci of this region, one or the other of these will probably be broken. When the violence is received over the occipital or posterior portion of the head, the force will be accumulated at the basilar process of the occipital bone, reaching in this way the posterior or cerebellar fossa; but, as the basilar process rests against the apices of the petrous bones, the fracture may involve the middle fossa also.

The thickness of the cranial bones and morbid alterations of their structure constitute predisposing causes of fracture. The walls of the skull are frequently quite thin and will yield to a very moderate force, while in other instances they are very thick and are capable of resisting an incredible amount of violence. In the advanced state of syphilis we not unfrequently meet with such changes in these bones as render them quite brittle, and incapable of withstanding a very ordinary stroke.

Classification of Cranial Fractures.—Fractures of the cranium may be divided, according to *position*, into fractures of the *vault* and fractures of the *base*. They admit of another general division, based upon the degree of penetration,—namely, into *complete* and *incomplete*,—complete when the fracture extends through both tables, and incomplete when only one table is broken. Wherever situated, or whatever the degree, however, they are best arranged under two heads, *simple* and *complicated*. A simple fracture consists in a mere solution in the continuity of the fibres of the bone, without any external wound or implication of the cranial contents. A complicated fracture is one in which there is something superadded to the break in the bone, and which adds danger or importance to the injury. The complications are the following: 1, an external wound, constituting what is called a compound fracture; 2, location, when the fracture is situated at the base of the skull; 3, depression, in which the fragments of the broken bone are driven in, so as to encroach upon the cavity of the skull or upon the brain, with or without an external wound; 4, gunshot fractures, produced by fire-arms; 5, puncture, in which a sharp-pointed weapon, like an arrow-head, sabre, nail, bayonet, or walking-stick, penetrates the soft parts and bone.

Fracture by *contre-coup* is used in such a vague sense that it should be discarded from the nomenclature of cranial injuries. Strictly interpreted, it applies only to a fracture which takes place directly opposite to the point where a blow is applied to the head, an occurrence, I apprehend, which very

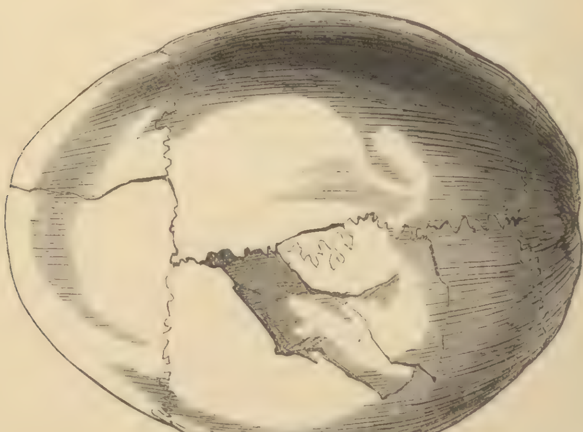
rarely happens, unless the opposite point is a fixed or resistant one, in which case it would not be properly a fracture by *contre-coup*. That fractures do occur at points opposite to the contact of violence is a matter of common observation; but these are examples of direct fractures. If a man falls headlong from a height upon the vertex, he is liable to have a fracture at the base of the skull, but in such a case there are two antagonizing forces,—the resistance of the ground and the weight of the body, plus its momentum, communicated to the base through the articulation of the spinal column with the occipital bone. Mr. Bryant reports the case of a man brought into Guy's Hospital* in a dying condition, who had fallen upon his head from a scaffold with such force that the summit of the spinal column was driven into the skull.

Causes of Cranial Fractures.—Fracture of the skull may be caused in various ways, as by falls upon the head, by blows, by punctures with sharp-pointed missiles, and by fire-arms.

The location and form of cranial fractures are often determined by the manner in which the injury is inflicted, and the form of the vulnerating body. When the head is caught between two opposite forces, the fracture is likely to be a double one, corresponding to the points where the pressure is applied. Where fractures take place in the vault of the cranium, they are usually the result of direct force. Fractures at the base of the skull follow diffused force, as where a person falls from a height and strikes upon the head, or is buried under falling timbers or walls. These injuries involving the base often commence in the vault and extend into the former, radiating in various directions, sometimes completely encircling the skull, and occasionally forcing asunder the sutures. In the case of a restaurant-proprietor to whom I was called, who had fallen from the third-story window of his house upon the brick pavement of the yard, a post-mortem showed a fracture passing round the cranium from vertex to base, separating the head into two parts, with also an antero-posterior division of its base. Diffused force applied to the skull will sometimes open sutures which have been long closed.

When the head is struck with a bludgeon or other blunt body, the fracture will generally be simple and without depression, but comminuted, and confined to the locality of the force. (Fig. 179.) When a blow is inflicted with an

Fig. 179.



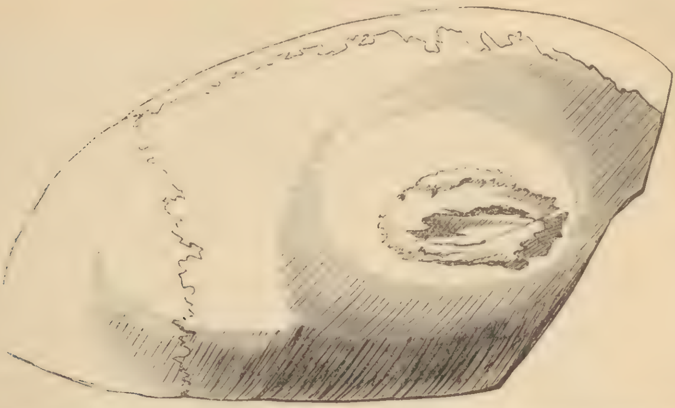
Fracture of the skull produced by a bludgeon.—From a specimen in the University Museum.

implement having a dull edge, as the side of a shovel, the back of a butcher's meat-cleaver, or the edge of a brick, the fracture will probably be an oblong

*** Guy's Hospital Reports, vol. v. 3d series.**

one, complicated with an external wound, and depressed. (Fig. 180.) When the vulnerating body is circumscribed and flat, like the pole of a hammer or

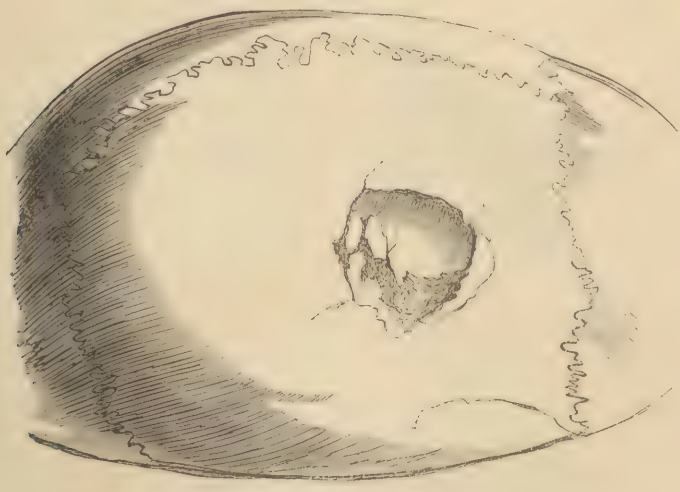
FIG. 180.



A fracture produced by the edge of a brick.—From a specimen in the University Museum.

hatchet, in which case the force is very concentrated, there will probably follow a starred, comminuted, and depressed fracture. (Fig. 181.) In all cases the internal table exhibits greater comminution than the external.

FIG. 181.



Fracture produced by the pole of a hammer.

(Fig. 182.) A piece may be completely excised from the cranium, down to the membranes of the brain, by a sabre blow; in which case the injury is called an incised fracture.

REPAIR OF FRACTURES OF THE SKULL.—When the separation between the fragments is not too great, union is effected by an intermediate fibrous tissue, in which are frequently deposited bone salts. This callus, so far as I have observed, is always intermediate. Were it otherwise, and should the callus occupy the cerebral surface of the fragments, it would be followed by irritation of the brain and its membranes similar to that produced by an exostosis growing from the inner table of the skull. Where fragments of considerable size

have been removed after comminuted fractures, the void is occupied by a fibrous membrane, which in time may become partially ossified.

Prognosis.—Fracture of the skull in itself is not a serious injury. The danger to be apprehended arises from the damage sustained by the contents of the cranium, and, however simple an injury of the head may be, a surgeon should be cautious in venturing an opinion as to its final termination. Very simple accidents prove fatal, while others which appear almost hopeless recover. I have seen a blow upon the temple with the closed fist produce death in a few hours, and I have known the skull to be broken in by an axe, lacerating the membranes of the brain and the brain-substance, and yet recovery follow without an alarming symptom. When the fracture is a simple one, situated in the vault, and without any decided concussion or any signs of compression of the brain, a favorable result may be anticipated. The addition of marked concussion to a case of simple fracture gives it a graver aspect. A depressed fracture is a serious complication, and when accompanied by compression of the brain, a very dangerous one indeed. Fractures which involve the base of the skull are in most instances fatal; and here, as elsewhere, it is not the bone lesion which makes the case so serious, but the meningeal and cerebral sequences. A moment's inspection of the base of the skull, through which pass the upper part of the spinal marrow, numerous pairs of nerves, and important vessels, is quite sufficient to explain the fatality of such accidents.

Fig. 182.

Comminution of the internal table in fracture of the skull.

The mortality of skull-fractures is very great. In 128 of such injuries brought into the New York Hospital, according to Lente, 106 died, a mortality of 82.8 per cent. Of 305 cases treated in the Pennsylvania Hospital during a period of forty-four years, 146, or 48 per cent., proved fatal.

Simple Fracture of the Skull.—The existence of a simple fracture of the skull must be a matter of inference. There are no signs which indicate its existence. If an individual receives a severe concentrated blow upon the head, and there follow symptoms of concussion or compression, we very naturally suspect the presence of a fracture, though it is quite true that such cerebral injuries often follow without any break whatever in the bones. Comminuted and even depressed fractures may exist without being detected. The extravasated blood which collects beneath the scalp serves to conceal them from the touch, or the break may be under the temporal aponeurosis and muscle and cannot be reached by pressure with the fingers. The swelling which follows the local violence will often mask the damage. If after a blow upon the forehead, or behind the ears, the overlying cellular tissue becomes infiltrated with air, crackling when pressed upon, we may very properly assume the existence of a fracture of the external table of the frontal sinus or mastoid cells, even if no other visible or tangible signs are present. There are certain topographical features of the skull which may lead the surgeon astray: such are the inequalities upon the surface, the depressions which result from the angular conjunction of bones, the results of syphilitic ulcerations, the lines of the sutures, and the presence of the Wormian pieces. All such sources of possible error must be kept in mind. There are, however,

cases in which a simple or a comminuted fracture can be determined with certainty. When, for example, a bone is broken in the line of the old suture, the mobility of the fragments can be recognized by pressure. Sometimes, when there is comminution, the finger can discover the movement of the pieces.

Treatment.—The indications in the treatment of a simple fracture of the skull are to secure reaction when there is concussion, and prevent the occurrence of inflammation. If the patient is cold and pale, with a small, feeble, and frequent pulse, and is in a state of semi-unconsciousness, he should be placed in bed, and heat applied to the epigastrium, along the spine, and to the lower extremities, by means of hot bricks, or bottles filled with hot water and wrapped in pieces of flannel. If the state of collapse continues over a few hours, it will be proper to administer a small amount of stimulus by the mouth, or, should the patient be unable to swallow, it may be thrown into the bowel. When given by the mouth, a single teaspoonful of good whisky or brandy in a little milk every hour will be sufficient, unless the collapse increases, when a dessertspoonful may be given every half-hour. If used in an enema, two tablespoonfuls, with the same amount of milk or beef essence, once in three or four hours, will be sufficient. The greatest caution is necessary in giving stimulants in such cases. The state of depression or collapse is one unfavorable to the ready absorption of the stimulants introduced into the stomach, so that there is danger of their accumulation, and of the reaction, when it does take place, becoming excessive. On the earliest signs, therefore, of recovery, such as vomiting, returning warmth and color, a fuller pulse, and improved consciousness, stimulants should be withdrawn and our remedies directed towards moderating arterial excitement and the cerebral congestion. The head should be elevated, and ice applied, either in a rubber bag or in bladders. In severe cases the head should be closely shaven preliminary to the application of cold, by which means its effect will be greatly intensified. Should the pulse become full and frequent, the temperature rise above the normal standard, the skin become hot, with headache and flushed face, general blood-letting will be required; or if the symptoms are not urgent, the local abstraction of blood by cups to the back of the neck will answer. When the vascular pressure upon the vessels of the brain has been controlled, the vantage-ground should be maintained by the use of tincture of veratrum viride, two to four drops every hour, until the diminished force and frequency of the pulse indicate its constitutional operation, when the dose must be either lessened or the intervals of administration lengthened, in order to avoid serious depression of the heart. The bowels should be kept freely open, as another means of attracting blood from the head, and care taken that the bladder is emptied. The patient once extricated from the immediate dangers of the injury, the next step is to prevent inflammatory sequences. For this purpose I know of no single remedy comparable to calomel in preventing meningitis and encephalitis. One-fourth of a grain every three or four hours may be given, and, if the bowels are moved more than twice in the twenty-four hours, a quarter of a grain of opium, or five drops of laudanum, should be administered sufficiently often to keep the evacuations within the proper limitations. The earliest evidences of the constitutional action of the drug must be the sign for either its withdrawal or its less frequent administration. Should the patient complain of headache and sleeplessness, bromide of potash, in doses of twenty grains once in two or three hours, will, after a few doses, usually give relief. During the first few days, when all our professional resources are directed against inflammatory complications, the diet must be of the simplest kind,—such as milk, toast-water, and chicken-water,—but when six or eight days have elapsed, a more liberal allowance of food may be permitted. Entire quietude of body and of mind is an important consideration in the management of such a case.

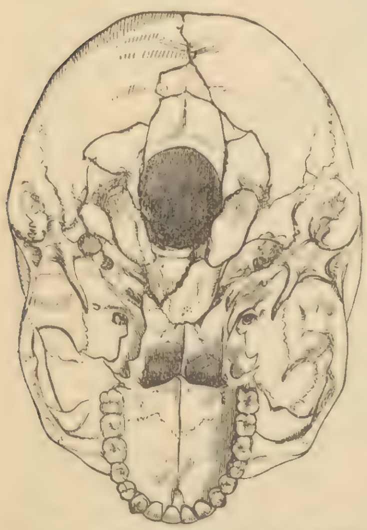
Complicated Fractures and their Signs.—When an external wound accom-

panies a fracture of the skull it is called *a compound fracture.* The wound in the soft parts is generally both contused and lacerated, and is rarely followed by the loss of much blood. The exposure of the cranium enables the surgeon to ascertain with certainty the presence of a fissure. The introduction of the finger into the wound, and a careful examination of the surface of the bone, will usually reveal even a slight irregularity; or if the bone is wiped clean with a soft piece of old linen, the eye will detect a red line corresponding to the breakage. The practice of scraping away the periosteum and staining the surface with a colored fluid like ink, which will sink into the narrowest crevice and form a persistent dark line, should never be employed, unless there is an urgent necessity for so doing.

When an external or scalp wound exists, as in compound fracture of the skull, the treatment will be the same as in ordinary wounds of the scalp, or that which would be proper in a compound fracture in any other portion of the skeleton,—namely, removal of the hair, arrest of bleeding, and closure of the wound by adhesive strips, so as to convert it, if possible, into a simple fracture.

Fractures of the base of the skull.—These may or may not be attended with an external wound, and when such is present it can have no direct communication with the bone lesion, save occasionally when the roof of the orbit is involved. They are rarely attended with much displacement, though occasionally after very great violence, and when the sutures are broken asunder, there may be marked depression or elevation of one or other of the fragments. They may be very limited and simple in character, confined to only a small portion of a bone, or they may encircle the skull, or radiate in various directions across its base. (Fig. 183.) When they involve more than a single fossa the determining force is usually a diffused one.

Fig. 183.



Extensive radiating fracture of the base of the skull.

Causes.—It is no ordinary force which produces a fracture at the base of the skull. In most cases this force is communicated from the vault and is diffuse in its character; as when a person is thrown with great violence from a carriage, or falls from a considerable height, the head striking the curbing or pavement of the street. The accident is not uncommon to sailors who tumble from a mast headlong upon the ship's deck. It may result from force directly applied, as in the two cases recorded by Mr. Hewett in his very valuable treatise upon fractures of the cranium, in which the condyles of the inferior maxillary were driven into the skull by a blow upon the chin. I have seen the accident follow direct force by a child falling upon a cane and driving its extremity through the orbit and the orbital plates of the frontal bone. A sailor was brought into the University Hospital who had fallen one hundred feet from the mainmast of a vessel. There was a wound over the right malar bone, and the man was unconscious, with heavy breathing and rapid pulse. In a few hours he died. An examination showed a separation of the articulation of the angular process of the malar with the external angular process of the frontal, a fracture of the orbital process of the former, and also one extending across the orbital plate of the frontal bone into the frontal sinus. In this case the fracture was the effect of direct force. A blow upon the nose may break the cribriform plate of the ethmoid, force being

communicated through the bony septum of the nasal fossa. In exceptional cases a fracture of the base may result from a fall upon the buttocks, or even upon the feet, the force reaching the skull indirectly through the spinal column. In speaking of the mechanism of fractures at the base of the skull, it was stated that they were found in three distinct localities corresponding to the three fossæ on the inside of the base of the skull, and that these maintained such a relation to the vault of the cranium that the locality of the impinging force, when acting from above, determined the particular fossa which the fracture would implicate.

SYMPTOMS.—The signs of fracture of the base of the skull will differ according to the region involved.

Fractures of the anterior cerebral fossa.—When occurring in this region, the most common symptoms are hemorrhage from the nose, loss of smell, due to disturbance of the olfactory bulbs which rest upon the cribriform plate of the ethmoid bone, and hemorrhage into the orbit, giving rise to sub-conjunctival ecchymosis. This blood may come from four sources,—the vessels of the dura mater over the orbital plates, the ophthalmic artery, the ophthalmic vein, and the cavernous sinus. The blood sometimes fills the orbit, protruding the eye, and forming a pulsatory swelling or false aneurism. When the body of the sphenoid is fractured, blood may flow either through the nose into the frontal sinuses or into the pharynx through the sphenoidal sinuses, and in this last way reach the stomach, and, when thrown up, may mislead the medical attendant, leading him to think that the case is complicated with hæmatemesis. These signs of hemorrhage and suspended olfaction are not decisive of fracture at the anterior part of the base of the skull. A blow upon the nose will produce not only an epistaxis, but also the loss of smell; and a similar injury over the eye may be followed by orbital hemorrhage. In the last, however, the eyelid will participate in the violence, and become blue or black from the effused blood, a condition which is not commonly present in the sub-conjunctival ecchymosis from fracture, though it may follow it should the bleeding continue long.

Fractures of the middle cerebral fossa.—In this fossa the petrous portion of the temporal is the part usually broken, though the fracture may implicate the adjoining bones. The symptoms which indicate the accident are hemorrhage, and the escape of the cerebro-spinal fluid from the ear, with paralysis of the face, and loss of hearing on the injured side. These phenomena are readily understood when the offices of the temporal bone are considered,—*i.e.*, as furnishing a chamber for the organ of hearing, a canal for the passage of the portio dura, and another tube—the external auditory—for conducting the vibrations of air to the membrana tympani. The paralysis sometimes extends to the muscles of the uvula and soft palate, indicating a lesion of the sphenoid, the spheno-palatine nerves being closely related to that bone.

Hemorrhage from the ears itself is an unimportant, or at least a negative, sign of fracture, unless profuse and continuing for several days. I frequently witness bleeding from the ear after injuries of the head and face, where there is no reason to suspect the existence of a fracture. Bryant relates a case of fracture of the petrous part of the temporal bone, in which the lateral sinus of the brain was laid open and the tympanum filled with blood; and a second, in which the internal carotid was torn where it passes through the bone, the hemorrhage finding its way into the pharynx and from thence filling the lungs. Neither case survived the accident over two hours.* The escape of a reddish or clear fluid from the ear is a sign of much greater importance than the flow of blood. Various surmises have been offered to explain the origin of this limpid or blood-stained fluid. Langier and Chassaignac supposed that it came from the serous part of the extravasated blood; other writers claim that its origin is from the venous channels or sinuses of the brain; and others, again, believe that it is a leakage from the labyrinth, the liquor Cotunnii. There can be no doubt, however, that the fluid in question

* Bryant's Surgery, page 50.

is the same as the cerebro-spinal, and that it is derived from the sub-arachnoid space. The observations of Robert, Hilton, and Hewett, and its analysis by Châton, all go to prove the identity of the two liquids. Hilton, in a case of a boy with fracture at the base of the skull, attended with a discharge of this fluid, performed the following experiment. Believing that if the material was cerebro-spinal in its origin it should be increased by cerebral congestion, he produced this condition artificially by compressing both internal jugular veins. In a short time the discharge was greatly increased in quantity, diminishing again after the removal of the pressure: the result proved the correctness of his theory.

This cerebro-spinal fluid is limpid in color, abounds in chloride of sodium, and contains traces of albumen and sugar. To permit its escape from the ear, it is necessary that the petrous portion of the temporal bone shall be broken, the dura mater and arachnoid membranes lacerated, and the membrane of the tympanum ruptured, when the fluid will trickle through the crevice into the auditory canal and be discharged externally. Should the membrana tympani not be ruptured, the fluid will take the opposite direction, and run into the throat through the Eustachian tube. The time at which this discharge appears after fracture varies. It may commence immediately after the accident, or it may follow a free hemorrhage. In some instances it does not appear for several days after the injury, and usually after eight or ten days it ceases to be discharged, the fissure being closed by inflammatory lymph. Errors are doubtless often made in regard to the true nature of watery discharges following injuries at the base of the skull. The blood-stained serum which commonly flows from a wound after the active hemorrhage is over may be mistaken for this cerebro-spinal fluid. A simple congestion of the Schneiderian membrane of the nasal and frontal air-passages will induce a free flow of a colorless fluid, the origin of which, if associated with local violence, might be misinterpreted. When, however, the discharge is limpid in its appearance, and immediately follows the accident, or when it occurs some time after the cessation of all bleeding and possesses the chemical constitution of the sub-arachnoid fluid, there can be little doubt as to its true source. The escape of the cerebro-spinal fluid is not confined to fractures of the temporal bone; it may flow into the nose or pharynx when the injury involves other portions of the base. It may also be discharged in compound fractures of the vault of the skull. It is difficult to estimate the quantity of this fluid which is lost, unless it is carefully collected in some vessel. It will saturate the pillows of the patient in a short time, and the flow has been known to reach from fifteen to eighteen ounces in a few days.

Fractures of the posterior or cerebellar fossa.—These fractures extend through the anterior inferior part of the occipital bone in different directions, running into the occipital foramen or through the basilar process, or involving both. Frequently cases are met with in which both the posterior and the middle fossa are broken at the same time; an accident which, so far as my observation extends, follows falls or blows upon the posterior part of the head.

The hemorrhage which follows a fracture through the posterior fossa may flow into the pharynx, in this way reaching the stomach, and be subsequently vomited, or it may extravasate into the soft parts about the neck and over the mastoid portion of the temporal bone, gradually finding its way to the surface and giving rise to a subcutaneous ecchymosis. Surgeons very justly attach much importance to this discoloration, as indicative of fracture, in cases where there has been no external contusion, and yet where the violence has been of a nature sufficiently severe to render such an injury probable.

The signs, therefore, which most clearly indicate fracture of the base of the skull are free and persistent hemorrhage from the ears, nose, and pharynx, and into the orbits, and the escape of cerebro-spinal fluid. The constitutional signs which follow fractures of the cranial base are those of concussion or compression.

Prognosis.—Fractures at the base of the skull are among the most dangerous accidents which can befall the human body, though not necessarily fatal. According to Robert, recovery never takes place where there is a loss of the cerebro-spinal fluid; yet I have seen two cases certainly, and I think three, in which the patients got well notwithstanding the presence of this discharge. In the first of the two patients, where the nature of the fluid was limpid, it was quite profuse from the right ear, and continued for about two weeks, having been preceded by a very free bleeding. The second case was one in which the frontal sinuses were crushed, and the orbital plate of the frontal bone comminuted, by the kick of a horse; the membranes of the brain were lacerated, and a considerable amount of brain-substance was discharged. The serous-looking fluid which saturated the dressings was too abundant to have been the product of inflammatory irritation of the lining membrane of the frontal sinuses. It had all the appearances of the fluid derived from the sub-arachnoid space. The man recovered, and in four weeks from the time of the accident he was again in the hospital, with a broken thigh. Notwithstanding occasional cases of recovery, the prognosis of fracture of the base of the skull is very unfavorable. It is not the fracture which makes the accident so grave: that may heal by fibrous tissue, or by an intermediate or an overlying deposition of soft bone. The danger consists in the consequences of the injury, such as inflammation of the membranes of the brain, inflammation, contusion, or laceration of its substance, and compression from the extravasation of blood.

Fractures with depression.—By a depressed fracture is meant a fracture in which the fragments are forced below the level of the surrounding bone. The danger of such an injury is apparent when it is considered that inasmuch as the brain fills the cranium, any depression of the walls of the latter, save in exceptional cases, must encroach upon the encephalon and give rise to consequences, immediate and remote, of a very dangerous nature. In the *diagnosis* of such injuries the following considerations must not be overlooked. *First*, the peculiar concave form assumed by extravasations of blood in the scalp after contusions. There are many instances where incisions have been made into such swellings under the impression that the depression existed in the bone. *Second*, there are localities in which, from structural peculiarities, depression may exist without encroaching upon the brain, particularly in the adult skull, as, for example, over the frontal and mastoid sinuses.

Varieties of depression.—Depression of the skull may exist with or without an external wound; the depression may be confined to either the external or the internal table alone; and lastly, it may involve both tables or the entire thickness of the bone.

Fractures of the external table.—Occasionally in civil, and often in military, practice, indentations or fractures of the external table are seen. I saw quite recently a very well marked case of the kind. A spent pistol-ball had struck the forehead of a man and rebounded into his hat. A considerable depression existed, without any signs of the internal table having been involved in the injury. In such cases the depressed portion of bone is accommodated in the spongy cancelli of the diploë without encroaching upon the brain. While this is possible at any portion of the cranial vault, yet those portions of the frontal and temporal bones which correspond to the frontal and mastoid sinuses, by reason of the wide separation of their walls, admit of the greatest inward displacement without compressing the brain. When the external table of the frontal or mastoid cells is broken, the nature of the accident is revealed by the escape of air into the overlying soft parts from either the nasal or the pharyngeal cavities, producing emphysema of corresponding portions of the scalp.

Fractures of the internal table.—The internal table may be broken and the external remain intact. Examples of this kind are given by Sir Astley Cooper, Velpeau, Adams, Hennen, Brodie, and others. I once trephined a patient for epilepsy, the internal table of whose skull presented a stellated

fracture without any break in the outer wall of the bone. There is a form of fracture produced by blunt-pointed bodies, such as nails or picks, in which the external table is traversed without much displacement, while the internal one is comminuted and extensively displaced. In all fractures of the skull which involve both tables the internal suffers more than the external. For the explanation of this fact there are three factors: first, its physical structure being the more brittle of the two; second, the operation of a law which determines a fracture first on the side of greatest extension, or, as iron-masters express it, on the "side of pull;" and, third, the mass of material carried before the fracturing force.

The law which determines a fracture of the skull is the same by whatever kind of force it is produced. The fibres of the bone yield first, as has been stated, on the side of extension, just as when a stick is bent over the knee the surface opposite to the point where the pressure is applied first gives way. The application of the law has been well illustrated by Tevan. A reference to the following figures will serve to make the explanation clear.

Let A B (Fig. 184) represent a portion of the vault of the skull, and C D and E F two vertical lines parallel with each other. If a force be applied to the convex surface of the section at G, the extremities of the arch, A B, will be separated from each other, and the section will assume the appearance of H I in Fig. 185. The effect of this separation will be to destroy the parallelism of the lines C D and E F and make the lines J K and L M converge at the upper and diverge at the lower surfaces of the bone. The effect of such a change is to force together the particles of the bone above at N, and to draw them asunder below at O, the point where the fracture, if present, will first take place.

Fig. 184.

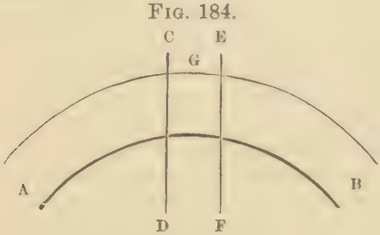
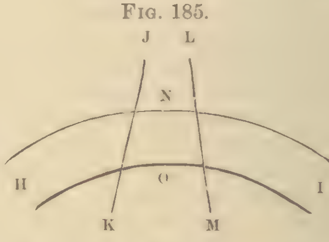


Fig. 185.



Fractures of both tables with depression.—Fractures of this nature may exist with or without an external wound. They are very often comminuted, and in some instances are broken in the form of pointed spiculæ, which puncture the membranes and wound the brain. These fractures may exist without symptoms of compression being present,—though generally the reverse is true,—but they are always fraught with danger from prospective consequences, such as hemorrhage, abscess, and, still more remotely, muscular weakness, defective articulation, epilepsy, and various mental imperfections.

Depression without fracture of the skull.—This cannot happen in an adult, but is occasionally seen in young subjects, and when present is usually of considerable extent, involving an entire bone. The explanation of this form of depression must be sought for in the mobility of the different pieces of the young skull, the sutures not being solidly closed. In a case of this accident which I saw with Dr. William Brinton, of West Chester, Pennsylvania, the depression was fully one inch and a half in diameter. It finally disappeared, the child making a good recovery. Extensive depressions are sometimes made by the forceps of the accoucheur, some of which are never effaced.

There are indentations which occur from pressure of various kinds, affecting portions of one or more pieces of the young skull (Fig. 186), and depending upon structural peculiarities in the bones, such as a deficiency in their earthy constituents, by which they are rendered flexible and supple like parchment.

Intra-uterine fractures of the skull are occasionally met with, and may

be produced by blows inflicted upon the abdomen of the mother, by pressure against the pelvic bones in protracted labors or in cases of deformity, and by the forceps when improperly placed upon the fœtal head.

Diagnosis of depressed fracture.—It is not always an easy task, in the absence of an external wound, to ascertain the existence of a depressed fracture. The blood effused beneath the scalp conceals the indentation. The symptoms of compression—if present—may be due to a clot of blood, and not to depressed bone. When the signs are urgent, the scalp should be incised at the seat of contusion down to the periosteum, so that the surgeon may determine the true nature of the injury by the finger and the eye. Where an external wound is present, communicating with the bone, there is no difficulty in determining the condition of the latter and in reaching a correct diagnosis.

Fig. 186.

A young skull with a number of depressions over its surface.—From a specimen in the Museum of the College of Physicians.

In regard to certain simple and compound fractures of the skull, the following observations may aid in determining the particular line of practice to be adopted.

1. *Fracture without depression.*—In a fracture of this kind, and in the absence of symptoms of compression, the treatment should consist of rest in the recumbent position, the application of cold to the head, gentle purgation, and a restricted diet. Should any cerebral disturbance appear, indicative of irritation or inflammation, such as headache, restlessness, intolerance of light or sound, with a frequent pulse, a more active antiphlogistic course will be demanded. Blood should be taken locally from the back of the neck and behind the ears, full doses of bromide of potash administered, and all causes of physical and mental excitement carefully excluded.

2. *Fracture with depression.*—When, in addition to fracture, the detached portion is driven down below the level of the surrounding parts, it constitutes the condition known as depression. This depression may exist in a very marked degree and yet not seriously encroach upon the brain; and in the absence of all symptoms of compression, the treatment will not differ from that appropriate in a case of simple fracture of the skull. No operation is proper.

3. *Fracture with depression and comminution.*—The additional element of comminution has furnished ground for a diversity of opinion among surgeons with reference to the best mode of treatment. This difference grows out of the fact that at some remote period there may be developed, in consequence of the irregularities of the fragments irritating the meninges of the brain, a degree of cerebral excitement which may culminate in epilepsy, or in the still more deplorable calamity, insanity. To guard against such evils, some surgeons advise laying open the scalp, applying the trephine, and elevating the fragments. In favor of such a practice we have the very high authority of Professor Gross. That convulsive and other forms of cerebral disturbance do occasionally follow such injuries, when the fragments are left undisturbed, I know very well, but, according to my own observation, as compared with those who escape such results, the number is very small; and the same effects are known to follow simple fractures even without depression. To trephine, therefore, under such circumstances, is to add to the danger of the original injury the double complication of a compound fracture and of exposure of the membranes of the brain, in order to prevent the evils of

exceptional cases. Hence I can see no reason for departing from what has been my usual course in such cases, namely, to refrain entirely from operative interference.

4. *Fracture with depression and signs of compression.*—In a fracture of this kind the displaced bone encroaches so much upon the brain as to give rise to unconsciousness, paralysis, noisy breathing, dilated pupils, and a slow pulse, —a group of symptoms which constitutes "compression." In the treatment of such a case some authorities advise an immediate resort to the trephine, while others inculcate delay, hoping that with blood-letting, cold, and time, the brain will become tolerant of the pressure and the compression pass away,—resorting to operative measures only when the symptoms persist. In the case of children it is best not to proceed too precipitately in the use of the trephine, as I have seen in such subjects very urgent symptoms disappear, in consequence, I think, of the movable cranial bones being thrust up by the pulsation of the brain. Such a result is not to be looked for in adults; and hence the sooner the depressed bone is elevated by mechanical means the better.

5. *Compound fracture with or without symptoms of compression.*—A compound fracture of the skull is one in which, in addition to the lesion of the bone, there is a communicating wound of the scalp. Such fractures are very dangerous injuries, and have various complications. The bone may be comminuted and depressed, the membranes torn, and the brain compressed and lacerated. They are usually attended with severe shock and considerable hemorrhage. The later dangers are from inflammation of the contents of the cranium, abscess, and fungous protrusions. Compound fractures with depression, whether accompanied by symptoms of compression or not, are proper cases for the use of the trephine or elevator. The existence of the external wound removes one objection to the use of the instrument. In cases of comminution the loose pieces of bone should be taken away. By so doing, one cause of irritation is removed and a free way of escape for the discharges is provided. In a number of cases I have seen a large quantity of the cerebral substance hanging from the wound, with extensive comminution of the cranial bones, and, after extracting the pieces and dressing the parts, recovery has followed with singular rapidity. Indeed, the greatest success I have had in the use of the trephine has been in cases which, from the extent of the damage done to the skull, seemed to be almost hopeless. After the elevation of the depressed portions of bone and the removal of loose pieces, the soft parts should be placed in position, but without any attempt being made to close up the wound tightly. A free vent to blood and other accumulations must be allowed, and, to prevent inflammatory sequences, cloths wet with cold water should be applied to the head and frequently renewed, small doses of calomel administered every three or four hours for the first few days, and a very restricted diet allowed.

Fig. 187.

Fracture through the frontal suture.—From a specimen in the University Museum.

Separation of the sutures.—The skull may be broken through in the line of a suture. Such an injury is the result of no ordinary force: hence in those cases where the base of the cranium is broken it is not an uncommon event to find some of the sutures disjoined. In the vault of the cranium, the sagittal and the coronal are those that generally suffer. Even when a suture is obliterated by ossification, as is often seen in the frontal part of the sagittal, a fracture

may follow its course with the greatest accuracy. Such a case is shown in Fig. 187, the separation being the result of a stroke with a flat piece of iron.

Punctured Fractures.—Such fractures often occur in the neighborhood of the orbits, and are produced by walking-canes, nails, umbrella-handles, or picks. I have seen cases where children while playing with "grace-hoops" fell upon the rod used in this amusement, driving its extremity through the upper eyelid and the orbital plate of the frontal bone into the brain, and in two instances have removed portions of the latter which protruded from the wound, recovery following in both without any unusual symptoms.

Treatment.—In the treatment of this variety of fractures the course of the surgeon must be determined, not by the symptoms present at the time of the injury, but in view of those which are likely to follow as a consequence of inflammation of the brain and its membranes. Whenever, therefore, the puncture is situated in the vault of the cranium, the trephine should be employed, by which a way will be opened for the escape of all inflammatory products.

Concussion of the Brain.

Many writers take exception to the term "concussion" when applied to injuries of the brain, on the ground that the word is vague and indefinite. The same objection, however, would apply with equal force to compression and many other terms which are employed to express disease or injuries. In the sense in which I use the word—that of a determining cause of certain phenomena, and not the phenomena themselves—I can conceive of no better term than that of concussion. The force may be either direct or indirect; that is, violence applied directly to the head or transmitted along the spine.

There are four varieties of concussion: 1, cerebral vibration without visible lesion; 2, vibration followed by sero-sanguinolent transudation; 3, vibration attended with extravasation of blood; and, 4, vibration accompanied with laceration of the brain-substance.

1. *Cerebral vibration without visible lesion.*—In this variety the force, whether applied directly upon the skull and conducted through its bony walls to the brain within, or indirectly by being transmitted through the spinal column, produces a simple molecular disturbance of the cells composing the neurine.

Symptoms.—A man receives a blow of moderate force upon the head, or falls from a considerable height, alighting upon his feet. He staggers, perhaps falls upon his knees, but instantly rises, and then quietly sits down. For a few moments he is bewildered and confused; he cannot collect his thoughts; there is some pallor of the countenance; a perspiration breaks out upon the surface of his face, followed by yawning, nausea, and perhaps vomiting. In a short time, however, he regains his intelligence, is able to rise and walk, possibly with a slight tremulousness of the limbs, and in a few hours has entirely recovered from the injury. This is a case of simple cerebral vibration. If it were possible to open the cranium and examine the brain under such circumstances, the presumption is that the keenest eye, armed with the best instrumental aid, would fail to detect any appreciable alteration of structure; yet, were it feasible to carry the search into those delicate relations which subsist between the cells composing the brain-substance, we should doubtless discover a sufficient explanation of the phenomena.

Conditions analogous to this are seen in other parts of the body, and indeed sometimes in matter subject only to physical laws. For example, a person may take hold of some object and apply for a long time a great amount of muscular force, but at length the hand suddenly relaxes its grasp and drops powerless by the side. In this condition it may remain for a few hours and again recover its strength. If the arm could be dissected immediately after the occurrence, no pathological change would be revealed.

Passing to grosser matter, or such as is governed only by physical laws, we see a temporary alteration or suspension of these properties. A watch

falls upon the floor and immediately ceases to record the time. It is taken to a watchmaker, and after the closest scrutiny he fails to discover what has happened, but explains the condition as one of "jar" or "strain." A sudden shake will sometimes put the mechanism again in motion. If a magnetic bar of iron receives a violent blow, its power as a magnet is greatly weakened. These are some examples of the suspension of function and property by molecular vibration.

When the violence has been more intense, the symptoms will be more marked and urgent. Insensible, pulseless, and with flaccid limbs, the patient resembles a dead, rather than a living, man. The countenance is pale, the features are shrunken, the surface is cold, the pupils are sometimes dilated and at other times contracted, or, as is not unfrequently seen, one is dilated and the other contracted. The breathing, when once established, is feeble, quiet, and occasionally interrupted by a long-drawn sigh. The circulation is feeble and intermittent; the fæces and urine are sometimes passed involuntarily. More commonly the urine is retained, the bladder becoming greatly distended. Deglutition is either difficult or impossible, the surface is covered with perspiration, and the temperature ranges from 94° to 97°. The special senses, though not destroyed, are obtuse and greatly enfeebled. The eyelids remain closed, or, if opened for a moment, no notice is taken by the individual of surrounding objects. Ordinary sounds are not recognized by the patient, but when spoken to in a loud and commanding tone of voice and roughly shaken, a single word in response may be obtained, and that delivered in a short and petulant manner. The group of symptoms thus detailed belong to what is commonly called the stage of collapse or shock, and may continue for a single hour or for many days. As the vital powers begin to assert themselves, the second stage, or that of reaction, sets in. Vomiting occurs, which is an evidence of returning sensibility in the stomach, the pulse becomes fuller, less frequent, and stronger, the perspiration dries up, the warmth of the body returns, the color appears in the face, and the mental hebetude gradually passes away, followed perhaps by headache, a flushed face, and vertigo.

2. *Vibration followed by the transudation of a sero-sanguinolent fluid.*—In addition to the symptoms already detailed as accompanying simple vibration, there are certain peculiarities present which, I think, are indicative of brain-pressure. The stage of collapse is more pronounced and prolonged than in simple vibration, there is much greater difficulty in rousing the patient from the state of stupor, and the breathing is often noisy, though not stertorous. The patient frequently assumes a peculiar position in bed,—that is, curled up on the side, or in a state of general flexion, the legs being bent upon the thighs, the thighs flexed upon the pelvis, the head upon the chest, and the chest bent forward upon the abdomen. When forcibly turned over or compelled to change his position, the patient will quickly resume the original posture, manifesting no small degree of temper, and sometimes profanity, at the disturbance, and then relapses into a sullen or semi-unconscious state. The urine is frequently passed in the bed, as are also, though less commonly, the fæces.

There are other symptoms which, though not peculiar to this variety of concussion, are not unfrequently present; for example, a well-marked convulsion. This may occur in both adults and children, and usually takes place when they begin to recover from the first effects of the injury. A sudden accession of violent muscular tremors is sometimes present. The tremor may be confined to one side, or to one limb, or may affect the entire body, and, like the convulsions, manifests itself when the collapse begins to pass over. In some instances the patient will recover his senses for a short time and again relapse into a state of stupor, with labored respiration, and in fatal cases will gradually sink into a state of complete coma, with stertorous breathing, dilated pupils, and a rapid, feeble pulse. This state is one in which the borderline between concussion and compression has been passed, and the patient dies much in the same way as one who has a depressed bone, a clot of blood, or a collection of pus pressing upon the brain.

Morbid Changes.—The essence of this variety of concussion consists in the transudation of a bloody serum through the walls of the cerebral blood-vessels, which I presume is due to paralysis of their vaso-motor nerves, by which they are rendered incapable of regulating the amount of blood within their canals, and thus become over-distended. This change is analogous to that which we constantly observe in the stage of inflammatory congestion in other parts of the body. I have witnessed numerous cases of this condition. It may exist to a great degree and be overlooked, as the serum gravitates to the dependent parts of the skull or sinks through the occipital foramen into the spinal canal.

Hewett mentions a case* in which a patient was admitted into the Hôpital St.-Antoine who had fallen some distance upon the pavement. He was collapsed, and after a few hours died. The head was examined, and no evidence of any intracranial damage was discovered. The fact was incidentally communicated to Dr. Deville, at the time making the round of his wards, who, going to the dead-house, had the spinal canal examined, in which was found a great quantity of extravasated blood, extending up to the cavity of the cranium.

It must not be overlooked that death may be caused by lesions of other organs produced at the time of the concussion, and thus be wrongly attributed to the latter. Hewett mentions the case of a boy who fell from a considerable height. When brought into St. George's Hospital, he presented well-marked symptoms of compression, and shortly after died. The examination of the head disclosed a little extravasated blood, but not sufficient to account for the sudden death. When, however, the chest was opened, a rupture of the heart was found to exist, which at once solved the mystery. Mr. Hewett further declares that in all cases of death from head injuries which he has witnessed, the intracranial damage was sufficient to account for the result. The same in effect has been stated by Mr. Le Gros Clark; and in further support of the truth of these assertions it may be stated that in none of the cases which have been recorded by authors as cases of death without lesion was any examination made of the spinal canal.

A sailor was brought into the University Hospital suffering from concussion, the result of a fall from the rigging of a ship. Thirty-six hours after his admission he died. On making the autopsy there were no indications whatever of any structural change in the brain sufficient to explain the cause of death; but on removing it from the skull a large amount of bloody serum was found in the spinal canal.

3. *Vibration followed by extravasation of blood.*—In this form of concussion we have a condition which has been termed contusion of the brain.

Symptoms.—There are, so far as we know, no symptoms which unerringly indicate either circumscribed or disseminated blood-extravasation of the brain; yet the presence of muscular spasms of the limbs, with great restlessness, furnishes a reasonable ground for suspecting the existence of such a condition. Dupuytren believed that about the fourth or fifth day the disease might be recognized by the appearance of those symptoms which ordinarily indicate encephalitis. Sanson, on the contrary, believed that there were certain signs, such as great restlessness, unconsciousness, with spasms of the extremities, etc., which revealed at once the nature of the lesion. Such phenomena are witnessed frequently, though they are far from being invariably present.

A man was brought into the University Hospital with a fracture extending into the base of the skull, accompanied with great loss of the cerebro-spinal fluid through the ear. He died after the lapse of five days. The autopsy showed a diffused extravasation at the base of both the middle and anterior lobes of the cerebrum, and also within their substance. In this case the rolling from side to side was confined to the head, the restlessness was excessive, the breathing, though heavy, did not amount to stertor, the spasms or tetanic contractions of the limbs were violent and at first intermittent,

* Thèses de Paris, 1834, No. CXIX. p. 19.

and although the patient would forcibly resist any change made by the nurse in the position of his limbs, he could not be roused to consciousness.

In a fatal case of concussion which I had under care the prominent symptom during life was an irregular, labored, and noisy respiration, with great dullness over the posterior part of the chest. An examination after death showed a blood-extravasation in the medulla oblongata and intense engorgement of both lungs. The urgent symptoms did not appear until twenty-four hours after the injury.

In a third case which was brought into my ward, and which proved to be one of disseminated cerebral extravasation, the patient remained unconscious, with a loud, almost snoring, respiration, having a tetanic rigidity of the muscles of the limbs, a very high temperature, and twitching of the muscles of one side of the face. There was also a remarkable reflex irritability of the orbicularis palpebrarum muscle on one side, which when touched with the finger would contract with great vigor.

Morbid Appearances.—These consist of extravasations of blood, either central or peripheral. When central or in the substance of the brain, the blood may be confined to a small space, and, when so, corresponds to what is termed *circumscribed extravasation*. When disseminated extensively through the brain, appearing as little red points, it constitutes *diffused extravasation*.

These extravasations or minute blood-clots may be confined to the vesicular or gray matter of the brain, or they may exist deep in the substance of the white or tubular portion. The little clots form small cavities at the expense of the brain-substance, as we find that, when they are displaced or turned out, excavations remain, with irregular margins and a surrounding discoloration. These extravasations present the appearance of apoplectic clots. All divisions of the brain and all parts of these divisions are not equally affected by such lesions. It has been definitively settled by Hewett and others that, although these ecchymoses are possible in any part of the encephalon, yet the anterior and middle lobes of the cerebrum suffer most, and not only so, but that they are chiefly confined to the under surface of these lobes. In thirty-seven cases of this injury, according to Hewett, the posterior lobes were contused in four instances, the anterior in eight, and the middle in twenty-five. There are several reasons given to account for the greater liability of the middle and anterior lobes of the cerebrum to suffer from these clots. These parts of the brain rest upon the bony floor of the middle and anterior cerebral fossæ, in contact with the irregularities of these cavities, whilst the posterior lobes are supported upon a membranous base, the tentorium. These facts, though thought by Fano to have been altogether overlooked, were long since, as mentioned by Hewett, recognized by Sir Benjamin Brodie. There are regions also in which fractures at the base of the skull most frequently occur, because they fall within the compass of those converging lines of force which in passing from the vault to the base follow the shortest routes, and must necessarily affect severely the contents of this part of the base as well as the skull itself.

When the extravasation takes place in the cerebellum, the collection, like that in the cerebrum, is generally found on the under surface. The pons Varolii and medulla oblongata are least liable to suffer. In a fatal case of concussion which I had under care, the prominent symptom was an irregular and difficult respiration. On an examination after death, the extravasation was found in the medulla oblongata.

The appearances presented where the patient has survived some time after the injury indicate that the work of absorption has been in progress, as the clots have been absorbed and in their place are seen well-defined cicatrices.

When the blood-extravasation comes from the vessels of the pia mater, it will spread over the brain, giving its surface an intensely red color and forming what is termed *peripheral extravasation*. When the ecchymosis occupies this position, there has usually been noticed entire unconsciousness, with other signs which resemble those of compression rather than those of concussion.

When the vessels of the pia mater are ruptured, the injury is usually accompanied by laceration of the arachnoid and extravasation of blood into its cavity.

4. *Vibration followed by laceration.*—In this variety of concussion the brain-substance is torn, and the lesion is frequently found associated with fractures of the bones of the skull and injury to the meninges.

SYMPTOMS.—Where there is laceration of the brain in addition to those symptoms which have been detailed as belonging to concussion in general, there is usually great restlessness; the patient tosses from side to side, endeavors to remove his clothes, the limbs are kept in constant motion, the bed-clothing becomes twisted into ropes, and not unfrequently moans and sometimes frightful screams are uttered. The respiration in such cases may be quiet, the pulse slow, the pupils somewhat dilated, and the temperature little changed from the normal standard. The patient will often answer questions when asked. Though the urine is usually passed in the bed, it is not wholly due to incontinence, as there is no dribbling, and the bladder will retain its contents for two or three hours.

PROGNOSIS IN CONCUSSION.—A degree of uncertainty hangs over every case of severe concussion, and this suggests the propriety of giving a very guarded prognosis. When the patient reacts in a short time, with restored intelligence, senses unimpaired, and without a severe and persistent headache, recovery may be anticipated with a reasonable degree of certainty. If, however, the surface continues cold and the sphincters relaxed, and the heart remains feeble and irregular, the pulse becoming increasingly frequent in its action, with progressive stupor and a heavy, labored respiration, a fatal termination is foreshadowed. When a patient, after concussion, recovers his consciousness and again relapses into a state of stupor, or when there is a repetition of convulsions, with a snoring respiration and a marked fall in the temperature, the case is exceedingly unfavorable. Great restlessness, screaming, and a rapid pulse are infallible evidences of approaching death. When the reaction is excessive, accompanied by a full, bounding pulse, intense headache, delirium, and intolerance of light and sound, there is imminent danger of inflammation of the brain and its membranes, which will seriously complicate the case. As intracranial inflammation from traumatic violence begins usually about the fifth or sixth day, it is a favorable sign when this period is passed without any unusual symptoms. The occurrence of vomiting after concussion should be regarded as a favorable sign, indicating as it does a return of the suspended nerve-action.

TREATMENT.—The indications in the treatment of a case of concussion are, first, to establish reaction, and, second, to counteract intracranial inflammation. In very mild cases, in which the patient is merely stunned but recovers in a few minutes, nothing is necessary save to enforce a few hours of quiet for both mind and body. The brain is capable of regaining its orderly operations without any officious interference, and may be safely let alone. Where the shock is more severe and the concussion well pronounced, the surgeon must still be careful how he meddles, and should be content, for a time at least, to place the patient in the recumbent position, with the head low, removing all constriction from the neck, admitting a free access of air to the patient, and applying external heat to the spine, to the lower extremities, and to the epigastrium. If deglutition is unimpaired, a little water or warm tea may be administered from time to time. The common practice—prompted by the anxiety of friends—of at once administering brandy or whisky cannot be too strongly reprobated; nor would any sane physician for a single moment entertain a thought of abstracting blood. The first error leads to a dangerous reaction, the last to fatal collapse. If, however, the body continues for hours cold and bathed in perspiration, the heart feeble, and the consciousness increasingly difficult to rouse, stimulants become necessary, and should be administered by the mouth if the patient can swallow, or, if not,

they can be introduced into the rectum. They should be given in small quantities and at considerable intervals of time. The reason for such a course will be obvious when it is remembered that in the state of collapse absorption is in a great degree suspended, and if given too frequently the stimulants may accumulate, and when the mucous membrane of the stomach begins to resume its function they will enter the blood in such quantities as to lash the heart into excessive action, carrying the reaction far beyond the point of safety and increasing the risks of encephalitis. A single teaspoonful of brandy or whisky or one ounce of wine-whey every three-quarters of an hour, until the signs of restoration begin to appear, will be quite sufficient, after which these agents should be withheld. The disappearance of collapse and the commencement of reaction are the signals for marshaling our resources to moderate and control the action of the heart and arteries and to save the brain from undue blood-determination, especially at a time when the feeble condition of the walls of its blood-vessels renders them powerless to regulate their contents. To this end the head must be raised, and covered with an ice-bag or with cloths wrung out of cold water; the bowels should be thoroughly purged with an active cathartic; all strong lights and sounds should be excluded, and the diet ordered to consist of toast-water and milk. Should these means not prove sufficient, and should the fever increase, with elevation of temperature, a flushed face, injected conjunctiva, delirium, and muscular weakness, blood should be drawn from the arm, or be taken locally by cups from the temples, from behind the ears, and from the back of the neck. The head should be shaven, in order that the effect of the cold may be more decided, and mercury should be given in small and frequent doses. Sleeplessness and restlessness are best relieved by full doses of bromide of potash, half a drachm every three hours. Opium, when the bromide fails, will often produce the happiest effect in calming excitement and disposing to quiet sleep. The deodorized tincture appears to me to be the best form for its administration, and this may be given in doses of from five to eight drops every two or three hours, until the desired effect is obtained. When the acute symptoms are subdued, or should the patient exhibit signs of prostration, more nourishment can be allowed and a moderate amount of stimulants exhibited. Tonics appear to do well only after convalescence is established, and it is at this period that the surgeon must rigidly enforce the recumbent position. It is not safe to allow a patient to sit up, either in or out of bed, for at least ten days or two weeks after his attack is overpassed; and, as preparatory to this change of position, the head and shoulders, and finally the body, should be gradually raised by additional pillows, that there may be no sudden change in the cerebral circulation. I have seen a patient, after passing through all the dangers of concussion, suddenly perish from being allowed to get out of bed at once, without any of these preliminary precautions. Patients, after recovery from severe concussion, often remain pale and suffer from vertigo and feebleness of the limbs. In such cases, iron, rest, and a good diet constitute the best treatment.

Compression of the Brain.

Can the brain be compressed?—that is, can its components, by external or internal force, be more closely compacted together than when in their normal condition? This question has been often asked. I can see no reason to doubt that such compression is possible, though the discussion of the subject would have very little practical importance. The term compression is open to many objections when abstractly considered, as the brain may be subjected to pressure without any of the signs usually attached to the term; yet where the word is used as a conventional phrase there can be no confusion or misunderstanding resulting from its retention in the surgical nomenclature of cranial injuries.

Compression of the brain may result from four different causes,—depressed bone, extravasation of blood, inflammatory products, and foreign bodies introduced from without.

Symptoms.—The symptoms which characterize a typical case of compression may be arranged as follows: alteration of sensibility and motion, of respiration, and of circulation.

1. *Alteration of sensibility and motion.*—The patient is dead as to the external world,—is entirely insensible and unconscious. No impression can be made on the special senses which will be recognized, nor does any articulate word or sound escape the lips. There is paralysis, general or partial, according as the compressing cause affects both hemispheres of the brain or one; where partial, the paralysis will be on the side opposite to the injury. There is inability to swallow, with retention, followed by dribbling, of urine; the pupils of the eye are fixed in a state either of dilatation or of contraction; or one pupil may be dilated and the other contracted.

2. *Alteration of respiration.*—The breathing is noisy, snoring, or, as it is termed, stertorous, and puffing; the first due to the paralysis of the muscles forming the soft palate, and the last to a similar condition of the buccinator and other muscles about the mouth.

3. *Alteration of circulation.*—The pulse is full, slow, and labored, and sometimes irregular, beating from forty to sixty strokes in the minute. The temperature, in consequence of the diminished frequency of the pulse, is a little below the natural standard.

Diagnosis.—Typical cases of concussion and compression possess well-marked and characteristic distinctions, which may be contrasted with advantage in the following manner:

CONCUSSION.	COMPRESSION.
Unconsciousness incomplete; patient can be made to answer, though it may be briefly and in single words.	Complete unconsciousness; may scream into patient's ear at the top of the voice, but will receive no answer.
Special senses, though greatly blunted, are not abolished.	Special senses entirely suspended.
Power of movement not destroyed; if the position of a limb be changed, the patient will resist or bring it immediately into the original position.	Complete or partial paralysis; in most cases hemiplegia.
Respiration is quiet and feeble.	Respiration full and noisy.
Pulse feeble, frequent, and intermittent.	Pulse full and slow.
The stomach sickens and rejects its contents.	The stomach is insensible to any impression; no nausea or vomiting.
The fæces may be discharged incontinently, as may also the urine.	Bowels are torpid, and the bladder incapable of emptying itself, though the urine may escape by overflow.
Deglutition not destroyed.	Deglutition impossible.
Pupils variable, though generally contracted; the eyelids somewhat open.	Pupils variable, though generally much dilated, and the eyelids closed.
Temperature of the body less than natural.	Temperature almost natural; a little below the natural standard.

No surgeon, however, will have been long engaged in hospital practice before he discovers that these sharp differential distinctions are subject to great variations and modifications. I have frequently seen cases of head-injury presenting at first the signs of concussion, which after the lapse of a few hours became those of compression; others, again, in which the phenomena of compression, at first present, gradually glided into those of concussion; and still a third or mixed class of cases, in which it was difficult, if not impossible, to refer them to either one or the other division. In all cases of compression the condition which produces what is commonly known as concussion is in some degree present, but is masked by the predominance of the former. Notwithstanding these irregularities, however, there remain a large number of cases in which the time-honored distinctions hold good, and possess, therefore, a practical value. These distinctions and their causes may be formulated as follows:

1. When a person receives a violent blow upon the head by a stone, brick, or bludgeon, or is precipitated upon the pavement from a height, fracturing the skull and driving the fragments in upon the brain, which injury is followed immediately by insensibility, paralysis, a slow pulse, and stertorous respira-

tion, with perhaps a widely-dilated pupil, the case is doubtless one of compression from depressed bone.

2. When after a similar injury, with or without fracture, there follow only the ordinary symptoms of concussion, more or less complete, but after the lapse of a few hours, or perhaps a day or two, symptoms of compression set in, the cause in all probability is the extravasation of blood, which, leaking from the broken vessels, has only after some time accumulated in a quantity sufficient to compress the brain seriously. The different sources from which the blood may be derived are discussed under the head of *intracranial extravasation.*

3. When a missile, such as a ball, or other foreign body, is driven through the skull into the brain and the wound is followed by symptoms of compression, the cause is multiple, consisting of fragments of bone, the vulnerating body, and an extravasation of blood.

4. When, after an injury of the skull, with or without fracture, symptoms of compression set in, at some period between the sixth and the thirtieth day, the cause is generally the presence of a purulent extravasation or of an abscess.

5. When, in consequence of a fracture of the skull, with depression, symptoms of compression immediately follow, and after a time pass away, the inference is that the depressed portion of bone has been detached and thereby rendered movable, so that the elevation of the brain which takes place during the ventricular contraction of the heart and the act of expiration has been sufficient to raise the fragment into place. Such cases, however, are exceedingly rare. When the depressed portion of bone is in the temporal region and it rises without artificial aid, the act must be due to the temporal muscle pulling the piece to the proper level, after the paralysis consequent on contusion of its fasciculi has disappeared.

6. When, after a severe head-injury, with or without a fracture, the patient lies insensible, with general paralysis and with a quiet respiration, scarcely discernible, no sagacity can do more than surmise what intracranial lesion has occurred.

There are cases of compression caused by morbid growths in the brain and by constitutional syphilis, which, however, do not fall within the province of operative surgery, and consequently need not be treated of in this connection.

Intracranial Extravasation of Blood.

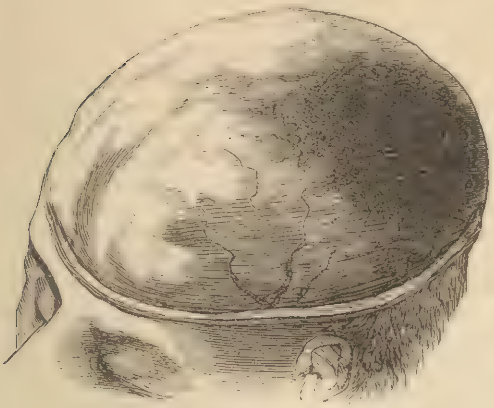
Intracranial extravasations of blood occur in five localities,—between the bones of the skull and the dura mater, in the cavity of the arachnoid, in the pia mater, in the ventricles, and in the substance of the brain. They may take place quickly, in a few minutes, or may form in a more gradual manner after the lapse of several days. In some instances the extravasation is confined to a limited area, in others it extends over a large surface.

The collections in the last two positions have been considered under the heads of concussion and compression.

Extravasations between the bone and the dura mater.—When a blow or a fall is received upon the head, the force is transmitted through the skull, and, if sufficiently intense, it will detach the dura mater from the bone. As the connection between the two consists in part of blood-vessels, some of the latter are necessarily broken, and an escape of blood follows, forming a clot (Fig. 188), which will be temporarily limited by the extent to which the separation takes place at the time of injury. If the large branches of the middle meningeal artery are torn, or the main trunk from which they arise, the hemorrhage will be profuse, quickly forming a clot, dissecting away the dura mater from the bone for a considerable extent (Fig. 189), and producing in a very short time well-marked symptoms of compression. When the bleeding is very slow, it may be many days before compression comes on, as the brain becomes somewhat adjusted to the gradual accumulation.

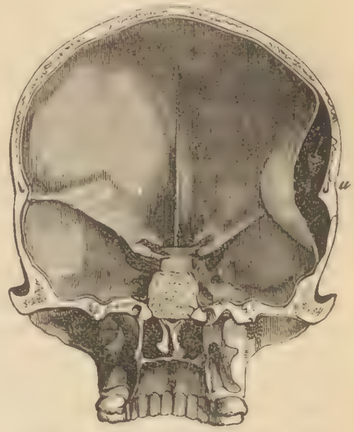
When a sinus is ruptured, the blood-extravasation takes place into the cavity of the arachnoid, though it may also find its way between the dura mater and the bone. It is said that the lateral sinus is oftener the subject of rupture

Fig. 188.



Clot of blood between the dura mater and bone.

Fig. 189.



Dura mater dissected from the bone at *a*, by a clot.

than either the longitudinal or the cavernous. The reverse has been true in my experience. A number of cases have been collected by writers in which the middle meningeal artery has been wounded. Dr. S. W. Gross has examined eight cases of gunshot injuries of the head in which this vessel was torn. A sailor was brought into the University Hospital with an extensive fracture of the side and base of the skull, from the effects of which he died. A very large clot of blood was found between the bones and the dura mater, derived chiefly from a wound of the middle meningeal artery a short distance above its entrance into the skull. Whether the hemorrhage comes from the rupture of a sinus or of the meningeal artery, the smaller vessels in either case contribute to furnish a certain amount of blood, as it is impossible to detach any portion of the dura mater from the bone without opening numerous blood-channels.

Symptoms.—The signs of extravasation of blood between the cranial bones and the dura mater are not always uniform. Where the bleeding is slow, in consequence of either collapse or a very circumscribed detachment of the membrane, the ordinary phenomena may not appear for several hours, perhaps days. The signs in well-marked cases are those of compression. The patient, after a blow or fall upon the head, passes into a condition of unconsciousness; the breathing, at first labored, becomes stertorous and puffing; the cheeks rise at each expiration, and the pulse is full and slow; the pupils are dilated, and there is paralysis and elevation of temperature on one side of the body. To these symptoms may be added retention of urine, and frequently loss of control over the bowels. Irregularities are occasionally seen in which none of these symptoms are present. In the case of a sailor brought into the University Hospital, who fell into the hold of a vessel, striking the head immediately above the external angular process of the frontal bone, and who died three days after the injury, there was no unconsciousness, even until a few minutes before his death, but only a slight degree of dullness. He was able to swallow without difficulty, and there was an entire absence of paralysis: indeed, the limbs were rigid and stiff, rather than powerless. The post-mortem revealed both a blood-clot beneath the dura mater and a fissure of the frontal bone. Irregularities are frequently seen in regard to the condition of the pupils after traumatic extravasation of blood. Instead of being dilated, they may be contracted, or one may be large and the other small. The

cause of the dilated pupil in compression is due to pressure upon the third cranial nerve. The pulse may also differ from the typical condition, and, instead of being full and slow, may be small, frequent, and irregular. There are conditions in which the traumatic origin of a clot and its location may be readily mistaken. A man may be seized with apoplexy and fall upon his head, inflicting a wound of the scalp or a fracture of the skull. If at the time of the attack no witness was present who could communicate the attending circumstances to the surgeon, the latter may be led into a great error by mistaking the cause for the effect. A person may be so profoundly intoxicated or narcotized as to exhibit symptoms closely resembling those of compression from blood, and aside from the odor of the liquor,* or some evidence of opium-poisoning, it would be very difficult to ascertain, at least for some time, the true cause of the condition. In most instances, however, a just conclusion can be reached from the history of the case. An individual receives a blow, or falls upon the head, or he is knocked insensible, or perhaps is only momentarily stunned. In a few minutes or an hour he is able to rise, and perhaps walks to his home, or is carried to a hospital. In a short time afterwards he becomes dull and drowsy, the pulse beats slow and full, he is roused with difficulty, and finally falls into a heavy sleep, with stertorous respiration, and paralysis of one-half of the body. Such a case is most probably one of compression from extravasated blood beneath the dura mater, and due to rupture of some of its vessels. Should the symptoms come on in a few minutes, and without fracture, either an extensive detachment of the dura mater has occurred or the blood issues from the large branches of the meningeal: if from the last cause, the clot will be located at the side and base of the brain. If the symptoms arise only after several hours, or it may be days, there is reasonable ground to infer that the detachment of the dura mater is at a point where the vessels are small and the flow very slow. In cases of depressed fracture, should compression follow the injury immediately, it will be due to the displaced bone: if after the lapse of some time, it will more likely arise from a clot of blood. The symptoms of compression from a blood-clot may be delayed even after a considerable separation of the dura mater, in consequence of the collapse succeeding a severe injury, by which the heart is so enfeebled that the circulation does not reach the torn vessels with sufficient force to overcome the combined resistance of their clots and that arising from the retraction and inversion of their tunics. As soon, however, as reaction sets in, these coagula are displaced, the bleeding begins, and the characteristic signs of compression appear. When in addition to the signs of compression there is present great restlessness, with disturbance of the muscular system and convulsions, the case is probably one of laceration of the brain-substance, and constitutes a most unfavorable complication, one which is by no means uncommon. Mr. Hewett† states that "the post-mortem records of St. George's Hospital show that within the last few years there have been twenty-five cases of large extravasations of blood between the bone and dura mater, in all of which the brain was more or less extensively lacerated."

Treatment.—Compression from extravasated blood beneath the dura mater can be relieved only by the removal of the cause, as the absorption of a clot in this locality rarely occurs. To do this it is necessary not only to make an opening in the skull, but also to know where it should be made. When a ball is lodged in the arm or leg, and is followed by constant pain or disordered sensibility within certain limits, even though remote from the seat of injury, its position may be inferred with considerable certainty from an acquaintance with the distribution of the nerves. When, however, we attempt to apply such a test to injuries of the brain, the analogy fails, not because

* Richardson, of London, has indicated a very simple method of distinguishing between the stupor arising from apoplexy or compression, and that from profound intoxication. In the first, the temperature differs little from the healthy standard; in the last, it is always considerably below. In some of the police stations of London thermometers are kept for the purpose.

† Holmes's Surgery, American edition, vol. ii. p. 258.

a connection between special regions of the encephalon and definite functions does not exist, but because there is such a mutual dependence between the different portions of the brain that disturbance of function from traumatic causes gives no clue to the seat of lesion. The similarity of phenomena from morbid influences acting upon the brain widely different in position has been ably brought out in the recent papers of Brown-Séquard. If, however, a depressed fracture exists, we have then a tolerably certain guide. If a severe contusion has left its traces on the scalp, though less reliable than the former, yet it is not without diagnostic value. But when neither depression nor contusion is present, how shall we interfere for the relief of the patient? In the absence of either of these signs, and if there is no paralysis, it is our duty to decline any operation, and to be content with keeping the head elevated, making applications of cold, and administering the fluid extract of ergot to excite contraction in the muscular walls of the injured vessels. If, however, paralysis be present, one point is gained: the extravasated blood is, as a rule, on the opposite side; but in what part? If the compression followed the injury very quickly, the inference is that the source of the blood is near the point where the middle meningeal enters the skull,—that is, near the anterior inferior angle of the parietal bone; and there should the skull be bored. The approach to this point must be effected through the temporal region. An incision should be made parallel with the course of the zygoma, and one inch above it, commencing about half an inch outside of the external angular process of the frontal bone. The skin, and the superficial and deep temporal fasciæ, should be divided in succession, securing any branches of the superficial temporal artery which may spring. The temporal aponeurosis should be opened by a crucial incision, by which a more ready access can be obtained to the deeper parts. The temporal muscle, thus exposed, requires to be divided vertically, and its fasciculi pressed aside in order to expose the bone, and any branches of the deep temporal which bleed should be secured by the ligature. Upon the portion of bone now uncovered the trephine can be applied, and after the removal of the piece, the meningeal artery, should the bleeding come from this point, may be tied, or the canal in which it lies plugged with soft wood or wax, or the mouth of the vessel sealed with the point of a heated knitting-needle. If by this operation we fail to discover the clot, we are to remember that the posterior branch of the middle meningeal is quite large, and, if torn, would pour out considerable blood in a very short time, and we may next proceed to trephine the skull over the inferior posterior angle of the parietal bone with a view to reach the vessel. Should this also fail, all further operative interference will be improper.

Extravasations into the cavity of the arachnoid.—As there is nothing to limit the extension of the blood in this position, it diffuses itself through the sac of the arachnoid, and may spread over the entire surface of one or both hemispheres. This blood appears susceptible of organization. In no other way can we explain the anatomical appearances of these extravasations. The blood, after undergoing coagulation, becomes inclosed in a membrane, which is often adherent to the reflected layer of the arachnoid, so that there are really two sacs, one within the other. At other times the blood-sac remains in a great measure disconnected from that of the arachnoid, lying loosely in its cavity. The vascularity of such blood-cysts would seem to depend on their connection with the reflected layer of the arachnoid, as vessels in considerable numbers, when such connection exists, pass from one to the other. The contents of these cysts are not always alike. In some a part of the original clot may be present, presenting various degrees of decolorization, and leaving a yellowish-green residue; in others the contents remain liquid, possessing the properties of blood-serum; in others again are found clots, some of which bear the marks of having been recently formed from the giving way of the vessels of the sac, and still others, doubtless, contain broken remains of the original coagulum.

These cysts are not peculiar to any age, and when the accumulation is great their pressure will affect both the brain and the cranial bones, flattening the former, and inducing absorption and thinning of the latter. If the collection is circumscribed, it will form for itself a cup-shaped depression in the surface of the brain, but if the extravasation is diffused, forming a cap for the hemisphere, there will be a general depression of the convolutions.

Treatment.—There are no signs distinctive of intra-arachnoid extravasation; therefore our treatment must be in a great measure empirical, and should be directed to the relief of symptoms which are due to brain-pressure. As this extravasation occurs in the sac of the arachnoid, the blood, meeting with no obstacle, will spread over an extended surface of the brain, on which account symptoms of compression will develop slowly or may be absent altogether. Diffused pressure is generally attended with headache, restlessness, loss of control over the temper, constipated bowels, and involuntary movements of the muscles. These symptoms may culminate in epilepsy or insanity. Whatever uncertainty of diagnosis there may be, there are certain remedies most clearly indicated, namely, the general or local abstraction of blood, the application of cold to the head, a brisk saline cathartic, and the bromide of potash in doses of twenty grains every three hours. Should there be much headache, the administration of small doses of a mercurial, both for its absorbent and its anti-inflammatory properties, will be productive of benefit. If the mercurial affects the mouth, it should be omitted, and the iodide of potash substituted, in doses of ten or twelve grains three times a day. The diet at first should be restricted, but should be made more liberal as the case advances.

Are there any circumstances which would justify the use of the trephine in cases of supposed intra-arachnoid hemorrhage? If a man receives a blow upon the head, and there follow, after several hours, compression of the brain, it would not be amiss to open the skull, guided by the contused soft parts, and apply the trephine. If the dura mater rises into the opening, it will indicate the presence of blood in the arachnoid, and the membrane should be punctured to admit of its escape. Several lives have been rescued in this way.

In a case which I trephined for a depressed fracture, this bulging of the membranes into the opening made by the instrument, caused by a collection of blood in the cavity of the arachnoid, did not occur until thirty-six hours after the operation, nor was there any movement communicated to the protrusion from the brain. The puncture, though followed by the escape of blood, did not save the patient, as there was extensive lesion of the brain beneath.

Extravasation of blood from the vessels of the pia mater.—An injury which produces rupture of the vessels of this membrane gives rise to a copious hemorrhage. The blood is not limited by peculiarities of structure, but becomes diffused, and may spread over the cerebrum, gravitating to the cerebellum, the medulla, and the spinal cord. The freedom of movement allowed the extravasated blood from the distribution of the pia mater explains the absence of blood-cysts in this membrane. It would be expected that where the blood is permitted to settle down to the base of the skull and into the spinal canal there would be less tendency to compression; but I have reason to believe that such is not the case.

This form of blood-extravasation is often produced by diffused force and affects both hemispheres. In two cases of railroad injury recently under my care, the symptoms of compression were well marked, and the diffused character of the effusion was predicated on the existence of general paralysis. The post-mortem showed the entire brain to be covered with a thin layer of extravasated blood, derived from the vessels of the pia mater.

There is a peculiar extravasation of bloody serum, which I have seen in fatal cases of severe head injury, derived from the vessels of the pia mater,

and unaccompanied by any evidence of brain-laceration or blood-clots. The only explanation for such a large accumulation of fluid without visible lesion, which occurs to me, is that of a vascular paralysis so modifying the vital properties of the walls of the blood-vessels of the brain as to favor a free escape of their liquid contents.

Treatment.—We have neither the means of ascertaining the presence of such extravasations nor the power to evacuate them, even could they be recognized. The same general and local measures are to be employed as in apoplectic attacks. The use of the trephine is never admissible.

Gunshot Wounds of the Head.

This class of injuries is exceedingly fatal,—especially so since the introduction of the conical projectile. The old round ball was frequently deflected after penetrating the integument, passing between the bone and the scalp, and either escaping at a distant point or lodging in the soft parts of the scalp; but the momentum of the modern missile generally carries it crashing directly through the skull and brain and driving fragments of the bone into the cerebral tissue. Some of the most terrible wounds of the skull are produced by fragments of shells. In whatever way caused, whether by balls or by portions of exploded shells, the prognosis will be unfavorable. Concentration and intensity of force confer upon all such injuries the gravest importance. The chief distinguishing feature between these wounds and those usually encountered in civil practice or from ordinary traumatic causes, is that in the former the external or visible injury appears unimportant and conveys no idea of the extent of the internal or invisible damage. There may be an opening in the integument or in the external table so small as almost to escape observation, and yet the skull may be extensively fissured, the internal table comminuted, the membranes and sinuses torn, and the brain-substance contused or lacerated. In the ordinary cases of head wounds which come into our hospitals, caused by the wheels of wagons, or by missiles like stones and bricks, giving rise to black-and-blue discolorations of the integument, swollen eyelids, free hemorrhage, and the detachment of large and irregular portions of the scalp, the external injury is no index to the internal, which may indeed be quite insignificant.

The evil consequences of gunshot wounds of the head are *immediate* and *remote*. Under the former or immediate consequences may be mentioned concussion, compression, and hemorrhage, and under the latter compression, inflammation of the brain, of its membranes, or of both, the formation of thrombi in the sinuses, abscess, pyæmia, necrosis of bone, muscular weakness, vertigo, headache, loss of memory, epilepsy, and paralysis.

Mortality of gunshot wounds of the head.—According to Macleod, during the Crimean War there were 630 cases of scalp wounds, of which 8, or 1.1 per cent., died; 61 cases of fracture of the cranial walls without known depression, 23, or 37.7 per cent., proving fatal; 74 cases of fracture with depression, with a mortality of 53, or 71.6 per cent.; 67 in which the skull was penetrated, 67, or 100 per cent., dying; and 19 in which the skull was perforated, 85.7 per cent. proving fatal. Alcock gives 28 cases of fracture, and 22, or 78.5 per cent., of deaths. Ménière, during the war in India, records 9 cases of wounds penetrating the skull, 84.4 per cent. resulting in death. The same author collects from other sources 10 additional cases of penetrating wounds, all of which were mortal.

The Surgical History of the War of the Rebellion, though exhibiting a heavy mortality, yields a more favorable result than that indicated by the figures already recorded.

Taking wounds of the scalp, incised, punctured, and lacerated, there were 669, with a mortality of only 2 per cent.; of gunshot wounds of the scalp there were 7739, with a mortality of 162, and most of these from inflammation of the encephalon.

The results of a summary of 4350 gunshot injuries of the cranium are exhibited in the following table:

	No. of Cases.	Recovered.	Died.	Undetermined.	Ratio of Mortality.
Contusions	328	273	55	...	16.8
Fracture of the outer table alone	138	128	10	...	8.7
Fracture of the inner table alone	20	1	19	...	95
Linear fissure of both tables	19	12	7	...	36.8
Fracture of both tables without known depression	2911	1001	1826	84	64.6
Depressed fracture	364	231	129	4	35.8
Penetrating fracture	486	68	402	16	85.5
Perforating fracture	73	14	56	3	80
Ecrasement or crash	9	......	9	...	100
Contre-coup	2	1	1	...	50
Total	4350	1729	2514	107	......

Excluding the 107 undetermined cases in the above collection, the general mortality from the different forms of shot injuries above specified is 59.2 per cent.

Gunshot injuries of the scalp.—Wounds of the scalp may be caused by fragments of shells, sabres, bayonets, or balls, and they may partake of the character of incised, lacerated, or punctured wounds. A missile, even though it strikes the head obliquely or at a very acute angle, merely grazing the bone, is likely to communicate a serious shock or disturbance to the encephalon. Should, however, the injury be confined to the soft parts, and be produced by a piece of shell or a conoidal ball moving with great velocity, the tissues will be damaged in such a manner as to produce some degree of sloughing, and, when the vessels of the pericranium are injured, cause exfoliation of the external table of the underlying bone. When the momentum of a ball is in a large measure expended, it may simply contuse the scalp without penetrating, or, if it effects an entrance, merely lodge between the soft parts and the bone.

Treatment.—The treatment of uncomplicated scalp wounds from the casualties of war does not differ from that proper to injuries of the same region met with in civil practice. Bleeding should be arrested, foreign bodies removed, the parts cleanly shaven and adjusted by adhesive strips or by the silver or hair suture, cool lotions applied, and absolute quiet enforced. Care must be taken, should an abscess follow, to have it opened early and at a dependent point, to insure drainage; and, as an additional precaution against the diffusion of inflammatory products through the sub-aponeurotic connective tissue, a recurrent bandage should be applied accurately to the head.

Gunshot wounds of the cranial bones.—These may be divided as follows: *first*, contusions of the bones without fracture; *second*, incised wounds and fractures of the external or internal table, or of both tables, of the bones, without impinging upon the brain; *third*, fractures with depression; *fourth*, fractures with penetration and perforation; *fifth*, crushing fractures.

1. *Contusions of the cranial bones.*—A ball or other missile may strike the skull without sufficient momentum to effect either a lodgment or entrance, and only produce at the time a slight degree of concussion, from which the patient after a brief period recovers, and yet the after-effects may prove very serious. I have seen men permanently invalided in this way from the disturbance to which the brain has been subjected, giving rise to severe headache, confusion of ideas, loss of memory, feebleness of the limbs, irregularities of muscular action, or defects in co-ordination, moral eccentricities, violent outbreaks of temper, epilepsy, etc. As these diseases may exist without any

serious impairment of the general health, the unfortunate victims are sometimes unjustly charged with malingering. These contusions are often followed by detachment of the dura mater, or by rupture of a sinus or of the vessels of the pia mater, giving rise to fatal compression of the brain from hemorrhage, also by laceration of the brain-substance and the formation of intracranial suppuration. In those cases in which death is represented to have followed contusions of the skull, without any detectable sign of injury to its contents, it is probable that the investigation has not been sufficiently thorough.

2. *Fracture without depression.*—These wounds differ, according to the nature of the vulnerating body and the angle of contact. When inflicted by the sabre, a part of the skull or its entire thickness down to the dura mater may be cut out (Fig. 190), so that it shall hang by the pericranium and scalp. The bones may be grooved to a considerable depth by the flight of a ball striking at an acute angle, or they may be fissured, the lines of fracture running in various directions. (Fig. 191.) Whenever the bone is furrowed, the danger

FIG. 190.

A sabre cut of both parietals.—Spec. 1672, Army Medical Museum.

FIG. 191.

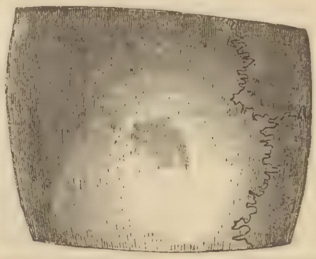
Fissured fracture.—Army Medical Museum.

of necrosis, pyæmia, and intracranial abscess is imminent. The internal table alone may be broken and the external table escape, the lines of fracture running in different directions. (Fig. 192.) The external table in such cases frequently becomes denuded at the place where the force is applied. (Fig. 193.)

FIG. 192.

Fracture of the internal table without injury of the external.—Spec. 2313, Army Medical Museum.

FIG. 193.

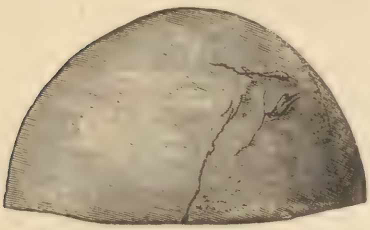


Denuded surface of the external table over the region of fracture of the internal.—Army Medical Museum.

The mortality following fractures of the internal table, it will be seen by reference to the table on the preceding page, is very great, amounting to 95 per cent.

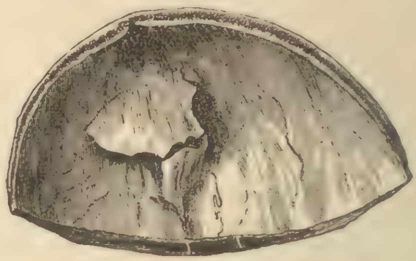
The external table may be fissured without displacement, and the internal table broken and extensively splintered. (Figs. 194, 195.) When the outer table alone is broken, it is an evidence of diminished velocity in the body producing the fracture, and hence the low mortality following such injuries,

FIG. 194.



Fissure of the external table of the skull.—Spec. 24, Army Medical Museum.

FIG. 195.



Internal view of the same, showing the splintering of the internal table.—Spec. 24, Army Medical Museum.

as will appear from the table, being only 8.7 per cent. In other instances the missile may comminute both tables, so that the fragments can be felt moving freely under the fingers, and this may occur both with and without compression of the brain. Terrible as these accidents appear, they are really less dangerous than those in which the tables are fissured. There are obvious reasons for this difference. Fissures are an evidence of intense and diffused force, or, in other words, are the result of a high degree of velocity in the projectile which produces them. The intracranial inflammatory products consequent upon such violence, being sealed up, constitute an additional element of danger.

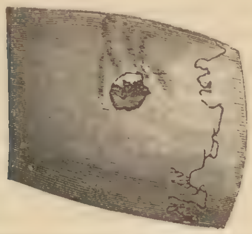
In comminuted fractures the fragments are often so movable as to yield to the motions of the brain and permit the escape externally of blood and other fluids. The termination of such cases, in both civil and military practice, is more favorable than when the bone is less extensively injured. I have had ample confirmation of this fact in my hospital practice.

3. *Fractures with depression.*—A ball or other missile may strike the skull, and produce a fracture with depression, without either lodging in the walls of the cranium or entering the cavity. This result will follow whether the vulnerating projectile be moving at a low or at a high rate of velocity. When the first is the case, it is necessary that the impact with the skull be in a great measure direct; and when the injury occurs under the second condition, the ball must strike at an angle more or less acute with the surface of the bone, otherwise it would either penetrate or perforate. A reference to the table on page 288 will show that the mortality-rate of such fractures is very low as compared with that of fractures without depression, being only 35.8 per cent.,—a disparity which seems altogether too great. If all the circumstances attending the 2911 cases on which the analysis was based had been ascertained, they would in all probability have explained the increased death-rate. In the Crimean War, out of 76 cases of fracture with depression and without penetration, 55 died.

4. *Penetrating and perforating fractures.*—When a ball enters the cranium it makes an opening of entrance smaller than that of exit. The former may be a round puncture without any fissuring of the external table, and yet the internal will be extensively broken by the passage of the ball plus the portion of the external table carried before it. (Figs. 196, 197.) Fragments of the internal table are often in this manner driven into the brain, tearing the membranes and lacerating its substance. Such fractures are in a vast majority of cases fatal. If death follows in twenty-four or thirty-six hours, it will be from shock and the extravasation of blood and serum; when the fatal result is longer delayed, encephalitis or abscess will ultimately destroy life. When

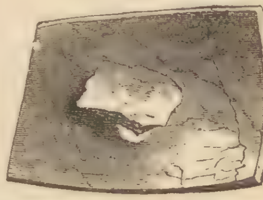
the projectile remains within the cranium, the danger is greater than when it passes through or perforates, as in the former case there is one foreign body more in the cranium. The statistics of our late war show a difference of 5 per cent. in favor of perforating over penetrating fractures, the mortality in the former being 80 per cent., and in the latter 85.5 per cent.

FIG. 196.



Gunshot perforation of the external table, showing opening of entrance, without fissuring.—Spec. 1473, Army Medical Museum.

FIG. 197.



Internal view of the same specimen, showing extensive splintering of the internal table.

Penetration of the skull is sometimes effected by sharp-pointed missiles, as bayonets, daggers, nails, ramrods, arrow-heads, and other similarly-formed bodies. Of six recorded cases of such wounds, five being inflicted by the bayonet and one by the sword, all died save one,* and he was rendered unfit for duty from an imperfection of speech, with pain in the cicatrix and head coming on after any excitement, mental or physical, and accompanied with defective sensation in the right arm. The puncture in this case was over the left parietal bone. The causes of death in the five fatal cases were—in one, extravasation of blood; in a second, hernia cerebri; in a third, encephalitis; and in the remaining two, abscess of the brain.

A remarkable case of penetrating wound of the skull is recorded by Dr. Harlow, of Vermont, produced by a tamping-iron over three feet in length and one inch in diameter, which was driven entirely through the head, entering at the angle of the lower jaw and emerging near the centre of the coronal suture. The direction taken by the iron was such as to render it probable that, in addition to fracturing the temporal, the sphenoid, and the parietal bones, and traversing the anterior lobe of the cerebrum, it wounded the superior longitudinal sinus. This patient recovered, and lived twelve years after the injury, though he suffered most of the time from mental peculiarities which rendered him unlike his former self, and he finally died in an epileptic convulsion.

5. *Crushing fractures* are those in which there is not only extensive comminution of the bones of the skull, but also divulsion of the sutures and laceration of the brain and its membranes. These terrible injuries are produced by solid shot, fragments of shells, and even by rifle-balls when fired at close range. Though a crash of the skull is generally instantaneously fatal, yet soldiers have sometimes survived two weeks after such an injury. A private in the Eleventh Pennsylvania Reserves was wounded at the battle of Fredericksburg, Virginia, December 13, 1862, by a shell which detached almost the entire parietal bone. He was sent to the Lincoln Hospital, at Washington, where he died on the 26th of December. He was able for some time to swallow food and drink, though in a condition of stupor. On his admission into the hospital, one-third of the left hemisphere had sloughed away, and at the time of his death almost the entire cerebrum had undergone a similar change.† Crash of the skull, however, possesses little interest for the surgeon, as it is uniformly fatal.

TREATMENT.—When the skull is broken, but not depressed, and there are no symptoms of compression present, the treatment will consist in establish-

* Surgical History of the War of the Rebellion, vol. i. p. 33. † Ibid., p. 212.

ing reaction (should the symptoms of shock be present), by placing the patient in the recumbent position, with the head slightly elevated, and applying external warmth along the spine and to the lower extremities. Where the reaction is slow, the patient being pallid and feeble, with a cold perspiration upon the surface of his body, a little brandy or whisky and milk may be cautiously administered, with a view to assist the recuperative powers of the system; but as soon as the evidences of reaction appear, such as warmth of the skin, a fuller pulse, a return of color to the face, a dryer skin, and perhaps vomiting, all stimulants must be withdrawn, and the head raised by an additional pillow. The danger of hopeless collapse being past, the next anxiety of the surgeon will be to prevent intracranial inflammation and its effects. In anticipation of this, bladders or rubber bags filled with broken ice should be kept to the head, and the bowels freely opened. If the circulation become too active and forcible, attended with headache, it should be controlled by tincture of veratrum viride, or by the general or local abstraction of blood. The importance of the use of mercury as an antiphlogistic cannot be overrated, and it should be given in all cases where, from the severity of the injury, there is reason to fear inflammatory sequences. The diet at first should be restricted, consisting of toast-water, light gruels, or a little milk, but after a few days it may be increased in quantity and quality. The condition of the bladder must be carefully inquired into, and the urine drawn when the patient is unable to relieve himself of the distention. Should symptoms of cerebral compression develop in the progress of the case, the question of instrumental perforation of the skull will arise.

When in addition to the fracture there is depression of bone, with the symptom of brain-compression, we have a complication which involves the exercise of much surgical judgment. The great question to be determined is this: When should the trephine be used to elevate the depressed bone? Upon this point there is some discrepancy of opinion. There are conditions in which the indications for operative interference are plain and admit of no discussion; as where there is an external wound, with comminution of the bone, its fragments being driven in upon the brain, with or without symptoms of compression being present, or where there is depression, with the signs of compression steadily increasing, even though there is no external wound. In punctured wounds also there can be little doubt about the propriety of using the trephine, in order to allow of a free escape of blood and inflammatory products. A diversity of opinion might occur in those cases in which, with marked depression, the signs of compression are not urgent. The frightful fatality which has followed the employment of the instrument in such cases has greatly restricted its use with military surgeons. Stromeyer states that in one of the battles during the Schleswig-Holstein War there were eight depressed fractures of the skull, with moderate symptoms of compression, which were left to nature, and all of which, with one exception, recovered. In the case which proved fatal there had been some meddling, as a number of pieces were extracted several days after the injury. During the entire war only a single instance of recovery followed the use of the trephine. The experience of English surgeons during the Crimean War harmonizes with that of Stromeyer, only four cases of trephining having recovered. With the French, as stated by Dr. Schrive, the operation was generally unsuccessful. We learn, on the authority of Dr. Williamson, as quoted by Hewett, that after the Sepoy mutiny in India no soldier who had been trephined reached Chatham,* although there were among the number eight cases of fracture of both tables of the skull with depression. In the later Franco-German War the operation was rarely performed. In the War of the Rebellion the results of the operation, as they are recorded in the "Surgical History of the War," are quite favorable to the use of the trephine, and in striking contrast with the general experience of military surgeons abroad. The operation was performed in 220 cases, 95 recovering, 124 dying, and one result being unknown,

* Holmes's Surgery, vol. ii. p. 178.

giving a death-rate of 56.6 per cent. In 454 cases the broken or depressed fragments were either removed or elevated by other means than the trephine, 275 of which number recovered, 176 died, and 3 remained uncertain,—a death-rate of only 39 per cent. Flattering as these results appear, until, however, we have ascertained, approximately at least, the exact nature of the injuries for which the operations were done, both as to structural damage and the cerebral symptoms present,—considerations which the distinguished author of the work himself fully recognizes,—it would be unsafe to speak with confidence on the subject, and especially where the weight of English, French, and German military surgical authority is directly antagonistic. I am inclined to believe that the truth lies somewhere between these two extremes, and that while the European practice has been too restricted, the American may have been too meddlesome. I cannot believe that the operation of cutting out a circular piece of bone from the skull is in itself serious, so long as the dura mater is not torn, any more so, indeed, than that of excising a portion of a rib and exposing the pleura costalis. The success following the use of the trephine when employed by the older surgeons for injuries of the skull, as compared with that realized by those of the present day, argues no superiority of judgment or skill on the part of the former, but simply proves that the old round ball was a harmless missile as compared with the modern conical one. The dangers arise from the original injury, and consist in the damage sustained by the brain and its membranes. In a paper published by Dr. S. W. Gross* there is a comparison instituted between the treatment of gunshot wounds of the skull by trephining and that by expectancy, with the following result. In 160 cases of such injuries in which the trephine was employed the death-rate was 60.62 per cent., and in 573 cases in which the expectant plan was adopted the mortality was 74.34 per cent. In 126 cases in which fragments were extracted or elevated by instrumental means without boring the skull, the mortality was 55.55 per cent. Comparing the results of trephining with the other modes of lifting or removing portions of bone, such as the elevator, forceps, or saw, the difference in favor of the latter is 5.07 per cent. of recoveries. The rate of recovery after all operative means was 41.61 per cent. By expectant or conservative methods the ratio of success was only 25.26 per cent., thus showing a result of 16.35 per cent. of recoveries in favor of the operative plans.

In cases of penetration, any exploration in search of the missile should be conducted with the utmost caution. It is impossible, after a probe has passed out of sight, to know whether it is following the track made by the ball or whether it is penetrating the brain-substance, and therefore, where the opening in the skull is sufficient to admit the finger, the latter should be used in preference to any other means of exploration. If fragments of bone or other foreign matters can be detected without needlessly pressing the examination, they should by all means be extracted; but, unless they are quite accessible and easily localized, all such attempts can only be productive of evil, and should be discouraged, the attention of the surgeon being confined to relieving shock and combating the succeeding inflammation. The quiet manner in which the brain tolerates the presence of foreign bodies is in some instances very remarkable. A case is reported by I. Palmer, Esq.,† of a soldier who, on account of drunkenness, was put into the guard-house, and on the following morning was sent to the hospital with some slight complaint. He remained in the ward two days, when he was suddenly seized with symptoms resembling those of apoplexy, and died in a few moments. On examination, a small wound was found in the left upper eyelid, which had been made by the stem of his pipe, part of which was discovered, surrounded by a collection of purulent matter, in the left anterior lobe of the brain. He had fallen on his pipe

* On Trephining after Gunshot Injuries of the Head, American Journal of the Medical Sciences, April, 1867.

† Dublin Journal of the Medical Sciences, vol. xi. p. 353.

while drunk, and the stem had penetrated the cranium without his being conscious of the injury.

M. Huppert* mentions the case of a man, aged forty-two years, who for more than forty years had enjoyed good health, but who for a year before his death had some mental disturbance consequent on an injury of the head. On examination, there was found in the brain a piece of slate-pencil three inches long lying in the white substance close under the right superior and lower cornua. The scalp and membranes were intact, but from the appearance of the occipital bone it was probable that the pencil made its entrance in early youth. It had caused no severe symptoms, but, as the writer suggests, it predisposed the man to suffer quickly and severely after the reception of what was a slight injury to the head. Sir Philip Crampton† reports the case of a gentleman who, in the winter of 1814, while an officer in a Highland regiment, received a thrust from an umbrella, the point of which struck him below the left eyebrow. He went home and had the wound examined, as it bled slightly. In the upper eyelid the wound was three-fourths of an inch in length. On the second morning after the accident a physician was summoned, who found him in strong convulsions, which lasted until nine o'clock in the evening, when he died. On examination, the brass ferrule of the umbrella was found in the left hemisphere of the brain, it having penetrated the orbital plate of the frontal bone. Dr. V. Biart‡ narrates the case of a man confined in the Kansas State Penitentiary, who attracted much attention among his fellow-convicts by boring a hole in his skull with an awl and introducing pieces of wire. The physician in charge removed several pieces which had pierced both cerebral hemispheres. The wound of entrance was situated in the right parietal bone, near its posterior inferior angle. He stated at the time that he had passed other substances into his brain. He was sent to the State Insane Asylum, and was perfectly well, with the exception of his mental condition. About a month after his admission he committed suicide by taking a large dose of morphia. At the autopsy the brain was found congested, and a wire three inches long and three-sixteenths of an inch thick was found running from the wound of entrance to the fissure of Sylvius; a flat nail, one and three-fifths inches long, was also found lying near the wire.

In the cavity of the arachnoid membrane, and glued to its surface by lymph, I once saw lying a needle, one inch and a quarter in length, the surface of which was considerably corroded. The subject was a young man about twenty-two or twenty-three years old, and had evidently died from some other cause than disease of the brain. The only theory I could suggest for the presence of the needle in such a locality was the probability of its having entered between the sutures of the cranial bones during his childhood, and before their close approximation.

In two or three instances a ball has been traced through the brain, localized on the opposite side, and removed by the trephine. The importance of removing a foreign body from the brain, when it can be done without too much injury to the organ, has been well shown by Dr. Wharton.§ In an analysis of 308 cases of foreign bodies of various kinds lodged in the brain, 167 cases were found to have terminated fatally, and 141 ended in recovery. In 104 cases the body was removed, recovery following in 68 cases and death in 36. In 204 instances in which the foreign body was not extracted, 73 cases recovered and 131 died. Of the whole number (308), 272 were the result of gunshot injury, of which number 124 survived and 148 proved fatal. In 86 cases the body was extracted, with 54 recoveries and 32 deaths. In 36 cases of penetrating wounds other than gunshot, the foreign body was removed in 18. Of these 36 cases, 17 recovered and 19 died. The term recovery, however, must be understood in a limited sense, for many

* Archiv der Heilkunde, 1875, pp. 97, 104.
† Dublin Journal of the Medical Sciences, vol. xi. p. 352.
‡ St. Louis Clinical Record, October, 1875, p. 150.
§ Thesis, by Dr. H. R. Wharton, University of Pennsylvania, 1876.

represented as "getting well" suffered afterwards with vertigo, mental disturbance, and epilepsy.

In the cases classified under the head of gunshot injuries, the missiles were musket- and pistol-balls, buckshot, and the breech-pins of guns. In the other cases the mutilating bodies were knife-blades, splinters of wood, ferrules of canes, stems of tobacco-pipes, wire, nails, and slate-pencils. The following table will place the subject in a perfectly intelligible form:

TABLE OF 308 CASES OF FOREIGN BODIES IN THE BRAIN.

Description.	No. of Cases.	Body removed.	Body not removed.	Recovered.	Died.
Result of gunshot injury	272	86	......	54	32
		......	186	70	116
Result of injuries other than gunshot	36	18	......	13	5
		......	18	4	14

Arrow Wounds.

Arrow wounds belong to the punctured class. During the early frontier wars with hostile Indian tribes, arrow wounds were quite common, but at present they are comparatively rare. Eighty-three cases of such injuries are reported in Circular No. 3* as having been inflicted upon different parts of the body. Twenty-six of these were fatal, and they were invariably so when the cavity of the cranium, chest, or abdomen was penetrated, and also when the larger bones and joints were implicated. The arrow-head

FIG. 198.

Iron arrow-head.—Army Medical Museum.

FIG. 199.

Buffalo rib pierced by an arrow.—Army Medical Museum.

FIG. 200.

Arrow in the head of a soldier killed by a Comanche Indian, with no fissure beyond the point of penetration. —Army Medical Museum.

is spear-shaped (Fig. 198), made of hornstone, quartz, or iron, having either smooth or serrated margins. When sped from a strong bow it moves with a velocity little inferior to that of a rifle-ball, and if within proper range will penetrate or transfix a bone as well as the soft parts. Fig. 199 is a good illustration of this fact. Punctured wounds of the skull are sometimes made by arrows, as in Fig. 200. It is said by Dr. Otis† that these wounds resemble incised ones, the arrow passing through both tables without fissuring or splintering the walls of the skull. This does not accord with the statement of Dr. Bill, who is the author of a very valuable paper upon arrow wounds,‡

* Surgeon-General's Office, Washington, D.C.

† Circular No. 3, Surgeon-General's Office, p. 150.

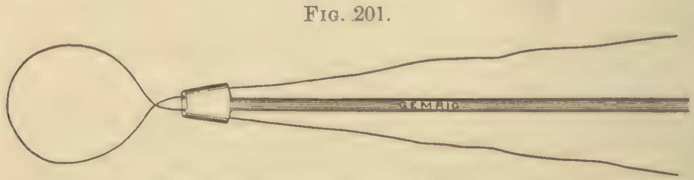
‡ American Journal of the Medical Sciences, vol. xliv. p. 365.

and who found after such injuries not only fissures of the external table, but also splintering and depression of the internal. The wound made by the arrow-head partakes of the properties of both a punctured and a lacerated one, and is followed by considerable suppuration. There is a popular notion that these wounds are also poisoned, in consequence of the treatment of the arrow-heads by which they are inflicted with certain animal poisons before being used. The practice is certainly not general, but in a great measure, according to army surgeons, is confined to a single Oregon tribe, the Pi-Utes. Of seventy-six cases of arrow wounds inflicted by Navajo, Apache, and Utah Indians, Dr. Bill saw no wounds which were poisoned ones. The poison used, as stated by the same author, is that of the rattlesnake, and it is prepared by first exposing the liver of some animal and provoking the reptile to strike it, thus emptying into its substance the contents of the poison-gland. The liver is next removed, wrapped up in the skin of the animal, and buried: after a few days, when decomposition has taken place, it is dug up, and the tips of the arrows are dipped in the decayed material. A few days later, when the adherent matter has become dry, the points receive an additional coating of blood, after which they are considered fit for use.

Treatment.—When an arrow has penetrated the skull, or other bones, the first step is to prepare an unobstructed way for its extraction. Mere traction will prove inadequate for the purpose, and should never be made through the shaft, as it will separate from the arrow-head and complicate the case. When it is deeply buried, the soft parts contract around its neck, or that part of the shaft where the point is connected with the neck, so that the expanded base and the serrations of its sides act like the barbs of a fish-hook, and resist withdrawal. The preliminary measure, therefore, is to ascertain, if possible, the direction of its surfaces, incise the track freely on either side of the shaft down to the margins of the dart, and then, grasping it with a pair of strong forceps, rock it from edge to edge until the impaction gives way, when a little traction will effect its removal. Should the missile be of stone, care must be observed not to exercise force in an improper direction, or it may be broken in two pieces. Additional difficulty will sometimes be encountered in the extraction of an arrow should its head be of iron, as it is liable to become bent in making its way between a bone and the overlying structures. Under such circumstances a great degree of force will be required to accomplish its removal.

When an arrow-head enters the cavity of the thorax or of the abdomen, the difficulties of extraction are greatly enhanced. It is in these cases that the attachment of the shaft is so important, since it serves as a guide to conduct a wire noose over the arrow-head, by which the latter can be drawn out. To apply this snare the soft parts must be laid open along the track to the end of the wound. A piece of soft iron wire should next be passed through either a double canula or a Cogshill wire-twister. (Fig. 201.) The loop projecting

Fig. 201.

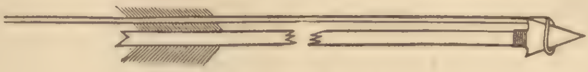


Wire passed through the Cogshill wire-twister.

beyond the end of the instrument should receive a single twist, and then be bent off at an angle, after which it is to be slipped over the projecting end of the shaft and thus slid down to the arrow-head. By drawing upon one end of the wire the noose will be made to encircle the dart (Fig. 202), and its extraction is effected by pulling both wire and arrow-shaft at the same time. Whatever may be the difficulties encountered, the extraction of the missile

is a paramount matter, and no device offering a reasonable probability of success should be left untried. When there is reason to believe that the

FIG. 202.



Dr. Bill's wire loop applied to the arrow-head.

internal table of the skull is splintered and depressed by an arrow-head, the use of the trephine will be as clearly indicated as in punctured wounds from other causes.

Injury of the Cranial Nerves.

Injury of one or more of the cerebral nerves is by no means an uncommon occurrence in cranial fractures, whether produced by gunshot or other kinds of violence. When the base of the skull is examined, and the number of foramina for the transmission of the cranial nerves considered, it is a matter of surprise that the injury is not more common. The evidence indicating such an injury is the loss of function belonging to the particular nerve involved. All are not alike liable to injury; the seventh, second, first, third, and fifth are those most commonly damaged. The causes which produce either the destruction, diminution, or suspension of function of the nerves differ in different cases. A ball may pass through the brain and completely sever a nerve. In such a case the loss of function is immediate, absolute, and hopeless. A violent or diffused force may fracture the base of the skull, lacerating or bruising to a greater or less extent the portio dura and the portio mollis nerves. The facial paralysis and the defect or loss of hearing sufficiently attest what has happened, and give additional strength to the probability of a fracture through the petrous portion of the temporal bone. A blow upon the nose may be followed by loss of smell, an evidence of injury to the olfactory bulbs, and perhaps fracture of the cribriform plate of the ethmoid. After an injury of the head the upper eyelid may drop, indicating a lesion of a branch of the third pair.

Paralysis may not appear for several days after an injury. Such cases are more favorable in their issue than when it comes on instantaneously, as in the first instance the cause is probably pressure either from blood or from inflammatory infiltration, and is therefore susceptible of improvement through the agency of the absorbents. It is possible to have a paralysis from concussion alone. I have seen instances of the loss of smell, and also of hearing, after a blow upon the head, in which there was no reason to believe that any fracture existed. In most cases the function is only suspended, and is in a few days recovered.

TREATMENT.—The surgeon in such cases can only address his remedies to the inflammation which must unavoidably follow; to control which the head should be elevated, local cold applied, and blood abstracted when indicated by severe and continuous headache. The derivative and depletive effects of purgatives, especially of the saline class, render their use very desirable in the commencement of the inflammatory symptoms, and, after their action, alterative doses of mercury should be given, either in the form of calomel or in combination with iodine.

Sequels of Head Injuries.

Inflammation of the brain or of its enveloping membranes from traumatic injuries of the head is exceedingly common. It is not necessary for such a result that extraordinary violence shall have been inflicted. It may follow wounds of the scalp, contusions of the bones, concussion, and fracture. The last, especially if there be splinters or fragments wounding the meninges or the brain,

is peculiarly prone to excite such action. There are two ways in which extracranial inflammatory diseases reach the interior of the skull, namely, by translation and by extension; most commonly by the latter. The vascular communication between the scalp, the bony walls of the cranium, and the dura mater and arachnoid, is quite free and direct. The temporal, occipital, frontal, and the meningeal branches of the internal maxillary arteries have a free inosculation in the diploic structure of the cranial bones, so that inflammation may extend readily from the exterior to the interior of the skull by continuity of structure. The pia mater and brain, on the contrary, receive their chief blood-supply from the internal carotid and vertebral arteries. These anatomical facts indicate what my experience confirms, that, except after concussion, inflammation of the brain, as a result of extracranial injury, independent of inflammation of the dura mater and arachnoid, is rarely seen, and that the former, when it does take place, is consecutive to the latter. In cases of depressed fracture, particularly when spiculæ penetrate the membranes and wound the brain, the inflammation of the latter will often take precedence of that of the membranes. As has already been hinted, in severe concussion also, whether from direct or indirect causes (especially the latter), encephalitis is first developed, and whatever of meningitis is found present follows as a secondary result, or by an extension of disease from within outwards, inasmuch as the vessels of the encephalon and those of the dura mater suffer most, in consequence of the disturbance or vibration communicated to the neurine which underlies and surrounds them.

Symptoms.—There are certain symptoms which indicate the existence of intracranial inflammation, but I know of none which are sufficiently uniform to enable us to differentiate between that which is meningeal and that which is encephalic. Among the earliest symptoms will be headache, and I think that local pain is most characteristic of commencing meningitis, whereas general or diffused pain points to encephalitis. This local suffering will, however, apply only to the initial stage of inflammation of the dura mater and arachnoid; the extension of the disease, a little later, will give a more general character to the pain. Restlessness, sleeplessness, and nausea constitute early signs of inflammation of the contents of the cranium, especially of the meninges. A supersensitive state of the organs of special sense indicates the existence of the same condition. Under such circumstances the pupils of the eyes become strongly contracted, and the light proves intolerable; loud sounds cannot be endured, and even the taste and smell become painfully acute. The pulse will be accelerated, the artery at first being small and hard, and having a quick beat, which as the disease advances will become fuller and less resistant; the eyes also will be injected and the face flushed. When the difficulty is meningeal, the temporals throb violently; when encephalic, the carotids. I mention this last sign with some qualification, as I have not observed it in a sufficient number of cases to warrant a confident statement as to its uniformity. The mind becomes unsettled, the delirium sometimes being of a quiet nature, at other times furious or maniacal, particularly when the gray substance of the encephalon is attacked. The secretion of urine is diminished, the bowels are constipated, and in cases where suppuration takes place there will be frequent rigors. As the disease advances, irregular twitchings of the muscles, tremors, spasms, and paralysis, followed by incontinence of urine, will occur,—a group of symptoms which some authors consider as indicating the implication of the white substance of the brain,—and finally death closes the scene, either by a convulsion or profound coma. In all advanced cases of brain-injury, a very frequent and feeble pulse, indicating a failure of the inhibitive power over the organ, may be regarded as a precursor of death.

Intracranial inflammation may commence in twenty-four hours after an accident, especially when the reaction following collapse is violent, overloading the vessels of the brain and membranes with blood; but, generally speaking, it does not arise earlier than the fourth or fifth day. When the

disease is developed through continuity of structure, passing from without inwards,—that is, from the scalp or contused bone to the interior of the cranium,—it may not set in for four or five weeks.

Morbid Appearances.—In fatal cases of traumatic intracranial inflammation, there will be seen on examination undue vascularity of the membranes, with opacity and thickening. If confined to the dura mater, as it may be in chronic inflammation, in addition to discoloration and thickening, pus may be found between the membrane and bone. When the arachnoid has suffered, its surface will be found covered with a thin film of lymph, its cavity often containing serum or a sero-purulent fluid, and the serum will sometimes fill the ventricles. When all the membranes have been involved, they are not unfrequently found firmly united, by organized transudation, to one another and to the brain. The morbid alterations noticed in encephalitis consist in a multitude of red points, which must not be confounded with the blood-specks of contusion: there are also present softening of the brain-substance, discolorations of various hues, and occasionally abscess.

Treatment.—It has been said that in the present state of our knowledge we are not yet in position to distinguish encephalitis from meningitis; but, fortunately, our ignorance on this point does not in the least embarrass the treatment. If the surgeon expects to rescue his patient, his course must be prompt and decided: there must be no compromise with the modern follies of expectancy, the result of which is well exhibited by the mortality of intracranial injuries during the War of the Rebellion, which, as stated by Dr. Otis, amounted to four-fifths of the cases treated, whereas under the antiphlogistic system practiced in similar cases by both English and German surgeons during their late wars, one-half recovered. It is a hand-to-hand conflict, and the value of minutes cannot be over-estimated. If there is reason to believe that a spicula of bone has penetrated the brain, the trephine should be used at once for its extraction. The moment that pain, restlessness, nausea, and an accelerated pulse appear, let the struggle begin. The head should be elevated, shaven, and covered with an ice-bag; blood should be drawn from the arm, and locally from the back of the neck. General bleeding should not be practiced recklessly: its effect on the pulse should be watched with great care, stopping the flow as soon as the artery begins to lose its force or resistance, but repeating the operation, if necessary. A brisk cathartic must be next administered, followed by tincture of veratrum viride to control the action of the heart. The effect of a purgative will be found valuable at intervals during the entire progress of the case. The value of calomel in alterative doses, with inunctions of mercurial ointment, so as to secure the constitutional action of the remedies quickly, cannot be over-estimated; while to relieve thirst, cold acidulated drinks should be given freely. To sustain the system for the first few days, barley-water, toast-water, and milk are quite sufficient. The violence of the inflammation being checked, the scalp should be covered with a blister, and restlessness, if present, relieved by the bromide of potash, or, that failing, by the use of opium in combination with the mercurial. It is important also that all strong light and loud sounds should be excluded. The convalescence is usually slow, and a relapse easily induced by any indiscretion on the part of the patient. He should not be allowed to sit up for two weeks after the subsidence of the disease, and then the change from the horizontal to the perpendicular position should be made in the most gradual manner. The bowels are to be kept open, and the food should be unirritating, being largely farinaceous. Stimulants must be avoided, and indeed an entire freedom from all excitement, mental or physical, is a very necessary precaution. Should abscess form, the surgeon must be governed by considerations already laid down.

Fungus Cerebri.—As a consequence of the loss of a portion of the cranial walls from a comminuted fracture, from necrosis, or from the use of the trephine, the protrusion of an intracranial growth frequently takes place, which

is designated fungus cerebri, encephalocele, or hernia cerebri. The last two terms have no appropriate significance when applied to this disease, and I shall use only the first, or fungus cerebri, as the most appropriate. The presence of this growth is supposed by some to be due to the absence of the necessary brain-pressure, as when the dura mater is torn in addition to the fracture. Velpeau thought that the disease was due to the expansibility of the brain under excitement, and that it was less likely to follow a large than a small opening in the skull. Flourens' views accord with those of Velpeau, the expansibility of the brain being considered to be produced by the distention of the blood-vessels at its base, consequent upon the absence of the usual resistance of a part of the cranial walls or of the dura mater. I doubt not that there is some truth in these statements, as it is certainly less frequently met with where the dura mater remains intact. Still, it is quite true that it sometimes arises even when the membrane remains unbroken, pushing it outward, until, in consequence of pressure, it inflames, ulcerates, or sloughs. Indeed, it is impossible to appreciate the conditions which determine such a production. I have seen cases in which there was not only extensive loss of bone, but also laceration of the membranes, with escape of considerable brain-tissue, and yet the patients made rapid recoveries without any tendency whatever to the formation of a fungus, while in other instances of a similar kind the disease sprang up in a few days and proved fatal. In other cases that I have observed in which the opening in the skull was quite small, the growths were often absent, but were sometimes present, and irrepressible. Fungus cerebri may appear in a few days after the injury to the head, or not for three or four weeks.

Morbid Anatomy.—The mass as it presses its way externally, rising above the level of the opening in the cranial walls and spreading mushroom-like over the surface of the scalp, presents a white irregularly-indented mass similar to the convolutions of the brain. (Fig. 203.) Sometimes it is quite soft and discolored with blood, at other times it is of a gray color and firm, consisting of softened brain-substance, nerve-fibres, white and red blood-corpuscles, fibrin, and serum. The vascularity of the growth varies, it being sometimes abundantly supplied with blood, at other times only moderately rich in vessels, and its sensibility, if any, exceedingly low. In other cases the brain-substance constitutes a very small portion of these growths, indeed, appears accidental to them, and without any vital connection, consisting of exuberant granulations, the result of inflammation induced either by contusion of the brain-substance or by the presence of blood. The collections of pus frequently seen at the base of the growth are results of this inflammation, and to the same cause are due the serous infiltration and softening of the brain-substance for some distance beneath and around the fungus, also the presence of blood-clots and the contiguous yellow or red discolorations. These alterations of structure may extend quite deeply, even into the ventricles, in consequence of the very scanty supply of connective tissue in the brain, by the presence of which inflammatory products in other localities are ordinarily circumscribed.

Fig. 203.

Fungus cerebri from a child whose skull had been broken by the kick of a horse.

Fungus cerebri may affect any part of the brain, but is most commonly seen at some portion of the vault of the cranium,—the part most exposed to open fractures and to lacerations of the membranes. The base would

perhaps be equally liable to such protrusions were there any considerable separation of the fragments after fracture in this region.

When after removal of bone and destruction of the dura mater a fungus makes its way through the opening in the skull, and also through the wound in the scalp, it spreads circumferentially, overlapping for some distance the soft parts, and having a mushroom shape. Portions of the surface farthest removed from its origin, having a lower vitality, become dark, soften, and separate from the main mass. The pedicle of the growth in some instances becomes strangulated by the margins of the opening through which it passes, and the entire fungus drops off as a slough, either to appear again or to be followed by cicatrization and recovery,—the latter a termination, unfortunately, very rare. During all this time the mental condition of the patient may be unimpaired. The usual progress of the disease, however, is from bad to worse: an irritating and offensive discharge flows from the surface of the growth; when it is rudely touched, quite a copious flow of blood may follow; the mind wanders; there are irregular muscular movements, especially of the face, broken sleep, startings up with a frightened air, emaciation, rigors, and a feeble pulse, which is at first slow, but becomes frequent and feeble as the case advances. The patient gradually wears out from exhaustion, or dies in a state of coma or convulsion due to inflammatory changes within the cranium affecting the brain and its membranes: not unfrequently he dies from pyæmia. Extensive softening and loss of brain-substance is often seen. I once examined the case of a young girl, in which almost one-half of the right hemisphere of the brain had entirely disappeared.

Though recovery occasionally occurs, a very large proportion of the cases die. Of fourteen cases recorded by a surgeon of Glasgow, twelve died; of three cases given by Mr. Stanley, two died; Mr. Hill reports three cases, all of which recovered.* During the War of the Rebellion, fifty-one cases of fungus cerebri, following gunshot wounds of the cranium, were reported, forty-four of which number terminated fatally. Of the seven who survived, four appear to have recovered perfectly without any mental or physical infirmity; the remaining three suffered so much from vertigo and headache as to be incapacitated for any continuous mental effort. It is proper to state that of the forty-four fatal cases eight were examples of brain-protrusion rather than genuine cases of fungus cerebri.

Diagnosis.—There are other growths which on a superficial inspection might be mistaken for fungus cerebri. 1. *A blood-tumor* may protrude, derived from the vessels of the dura mater, or, when the latter is torn, from those of the pia mater, and will occasionally contain some brain-substance. The early appearance of such a tumor—that is, a few hours after the accident, or at most three or four days, together with the homogeneous nature of the swelling, being for the most part blood throughout—will be sufficient to distinguish it from fungus cerebri.

2. *Malignant disease* occasionally originates in the dura mater, and as it increases the overlying bone is rapidly absorbed or is finally destroyed by caries, after which the growth protrudes as a fungoid mass. Between this and fungus cerebri there are certain notable differences. First, in fungus cerebri there is a previous history of injury, as of fracture with or without laceration of the membranes of the brain. No such previous violence is necessary to the existence of a malignant growth. In the latter disease the bone will become so thin, its salts disappearing at the same time, that it will crepitate, when pressed upon, like parchment; fungus cerebri never produces such an osseous change. In fungus cerebri, when its structure is opened, disorganized brain-tissue is seen mingled with its other components, which is not true of malignant fungus. Fungus cerebri is soft, friable, with little power of cohesion, and when its vessels are broken the blood adheres as dark clots or crusts over different parts of its surface; malignant fungus is much firmer, and bleeds from distinct points, the fluid being red, like arterial blood.

* Cooper's Surgical Dictionary, vol. i. p. 935.

Fungus cerebri frequently detaches portions of its substance as a slough; malignant fungus rarely does so.

TREATMENT.—There are two very opposite plans of treatment, the one aggressive, the other conservative.

In order to remove every cause which can possibly tend to develop the disease, the surgeon should be very careful to examine all compound fractures of the skull for depressed splinters. These are vastly more dangerous than scales or flat fragments of bone. They penetrate the membranes and wound the brain, or, even should they not do so, they produce irritation of the dura mater, which is almost certain to develop intracranial inflammation, ulceration of the membranes with protrusions, and often epilepsy and abscess. Hence in the use of the trephine the utmost care should be observed not to harm the dura mater.

When the fungus is once established, the practice with some surgeons is to repress the growth, either by compression with pledgets of lint or a sponge, or by excision, slicing the mass off on a level with the bone and then applying compression over the pedicle. The conservative plan, which has its advocates, is to meddle as little as possible, simply keeping the part clean by a gentle stream of water, and attending to the inflammation within, which is the cause of the protrusion.

In the application of pressure the chief danger is to the brain. When too great, it is often followed by stupor or much uneasiness, and should be immediately removed or lessened. No harm can come from making pressure upon that portion of the growth which spreads over the scalp beyond the limits of the opening of the bone: indeed, it is highly proper that this should be done. The plan which fulfills most satisfactorily the object is to take a piece of lint cut into a circle, large enough to extend a little beyond the limits of the fungus; out of its centre remove a portion somewhat larger in circumference than the opening through which the protrusion takes place, wet the lint with a solution of boracic acid or lime-water, place it over the mass, and secure it firmly to the shaven scalp with strips of adhesive plaster, except over the central orifice, where the strips should be loosely applied, leaving an interspace for the escape of any discharges; or it may be shaved off boldly on a level with the scalp, and a piece of perforated lint, wet with the same liquid as in the other dressing, laid over the pedicle and made fast by adhesive plasters, which should only cover the margins of the pledget, and not pass over the opening in the scalp containing the fungus. By this plan the vessels of the brain receive a certain amount of support, which assists in diminishing the amount of blood circulating through their canals, and consequently repressing in some measure the luxuriant growth of granulations, just as an ulcer is improved by strapping. Still, the great cause of fungus cerebri—namely, inflammation—must be kept prominently in view, and all local and constitutional measures employed to remove it. With this object the head must be elevated, blood taken with cups from the back of the neck, ice kept constantly to the scalp, the bowels freely purged, and the force of the cerebral circulation diminished by the use of aconite or veratria.

Epilepsy.—Considering the vast number of cranial injuries from all causes, epilepsy, as a consequence of such, is rather uncommon.

While depression is not a necessary antecedent for the production of epilepsy, in a large majority of cases under this head such a state of the bone is seen to exist. This affection is often preceded by defective memory and articulation, and by inability to sustain any connected train of thought or transact ordinary business. After some time there may follow a momentary loss of consciousness, or a peculiar, indescribable sensation in the head, and finally the development of true epileptic convulsions.

Should the trephine be applied to excise old depressed portions of bone which, by irritating the membranes of the brain and the brain itself, provoke this distressing disease? La Motte, seventy-five years ago, was the first to use the instrument for this purpose, and there can be no doubt that under

certain conditions the operation is not only proper, but even urgently demanded. It is the apprehension of this disease that induces some surgeons to apply the trephine in cases of depressed fractures, even when no urgent symptoms are present. The danger from this source I believe to be very much exaggerated.

In a paper by Dr. Billings on the subject of trephining for epilepsy, sixty-two cases are collected, of which number forty-two were cured, sixteen died, and four remained without improvement. Professor Gross* has operated four times, with one cure. I have trephined in three cases of the disease: one recovered, one was greatly relieved, and one died. The depression of bone in two of the cases was quite marked.

FIG. 204.

A disk of bone taken from the head of an epileptic, showing comminution of the internal table; followed by cure.

The patient who was cured was a young man. The left parietal bone had been fractured by the point of a mattock, close to the sagittal suture, eleven years previously. He remained almost insensible for twenty-four hours, and afterwards gradually recovered. For six years no inconvenience was experienced, after which time he was attacked with epilepsy, the convulsions occurring almost daily, at times numbering as many as eleven in the twenty-four hours. The memory was impaired, though not to the degree which I have often seen. The depressed portion of bone (Fig. 204) was cut out with the trephine, revealing a depressed comminuted fracture of the internal table, with marked thickening of the dura mater beneath. The patient recovered, and now, after the lapse of several months, I learn that he remains entirely well.

The second case was that of a man about twenty-seven years old, a foreigner by birth, who, seventeen years before coming to America, had had his skull fractured by a beam of timber falling upon his head, and who, after recovering from the immediate effects of the injury, became an epileptic. The frequency and severity of the convulsions produced such an uncontrollable irascibility of temper that his parents, unable to exercise over him the needful control, were compelled to send him to the Philadelphia Almshouse Hospital for the Insane, in which place I found him while making the round of its wards. There was a linear depression of the external table, about three-quarters of an inch in length. Believing the case to be a proper one for trephining, I made the operation before the medical class attending the clinical instruction of the hospital. The patient had a convulsion on the table during the administration of the anæsthetic. After removing the bone there was found a stellated fracture of the internal table, with a rough, discolored thickening of the dura mater, but without evidence of depression. For four weeks he had no attacks, and was discharged from the house. Afterwards I learned that the convulsions returned, though greatly diminished in frequency, intensity, and duration, so that he became quite docile and lived happily at home.

The third case was that of a young man about twenty, greatly enfeebled mentally and physically, with an extensive depression in the left temporal region, the result of a fracture received ten years previously. The dura mater had been wounded by the splintering of the internal table. This patient died from encephalitis.

The conditions, in my judgment, which justify the use of the trephine in cases of epilepsy following fractures, are the occurrence of very frequent attacks, progressive weakening of the mental faculties, and the failure of remedies to control the disease. I have never seen much advantage from the use of the bromides when the disease was caused by depressed bone.

Pain in the head.—This is often a troublesome sequel of head-injury. Sometimes it is localized or confined to a small spot, when it should always be a source of anxiety, indicating as it does that some brain-mischief is going on,

* Surgery, vol. ii. p 177.

such as softening or abscess. Diffused pain, particularly under mental excitement or when exposed to solar heat, is a less serious condition, though not altogether without danger. These pains are often aggravated by exposure to inclement weather.

Vertigo is a very common sequel, a fact well illustrated in the Surgical History of the late war, where it is stated to have been very common after contusions of the cranium, rendering, in many cases, the patients incapable of subsequent service.

Mental defects.—Under this head may be mentioned loss or impairment of the memory, inability to express ideas or to pursue processes of reasoning, a capricious temper, loss of language or aphasia, imbecility, and insanity.

Involvements of the muscular system.—These conditions, dependent upon intracranial irritation or abscess, consist in feebleness of the limbs, spasmodic contraction of the flexors, tremors, twitchings, or paralysis affecting one side of the body. The genito-urinary apparatus often suffers, the patient losing power over the bladder or being subjected to the annoyance of great vesical irritability, the urine being often loaded with phosphates and mucus. Occasionally the urine is albuminous, or it may be greatly increased in quantity and become saccharine, constituting what is termed *traumatic diabetes*, the pathology of which, though supposed by some authors to consist in structural alterations of the floor of the fourth ventricle and by others ascribed to imperfect oxygenization, yet really has never been determined with any degree of certainty. Sometimes there is complete impotency, while in other cases there is inordinate sexual excitement, accompanied by painful erections.

Derangements of the organs of special sense.—These derangements may involve the eye and its appendages, and consist in the loss of the power of accommodation, the presence of double vision, glaucoma, conjunctivitis, ptosis, etc. The sense of olfaction is sometimes lost, or it may be perverted, the patient complaining of the presence of strange odors. The hearing may be rendered obtuse or utterly destroyed. In some instances there are unusual sounds experienced, like the hissing of steam, the ringing of bells, or the roar of the sea. These cause great distress. Scarcely any organ of the body can claim exemption from the far-reaching effects of head-injury. The function of the liver may be disturbed, producing traumatic jaundice, and the heart may become preternaturally excitable or depressed.

Pyæmia.—Pyæmia is by no means so common as abscess, though the peculiar arrangement of the venous system of the diploë would indicate the contrary. Dr. Otis states that the returns of the army show but a single case in which the disease was referred to this cause.

Tetanus is quite rare as a sequence of head-injuries.

TREATMENT.—The exact nature of the meningeal or brain condition on which depend the sequels that have been enumerated is so obscure that our treatment must be largely empirical and directed against the symptoms as they arise. Entire freedom from all mental and physical excitement is of the first importance. Solar heat must be avoided. The readiness with which reflex impressions reach the brain from disordered states of the gastro-intestinal mucous membrane will suggest the necessity for keeping the bowels regular and avoiding the use of all articles of food calculated to disturb the digestion. The state of the kidneys should be ascertained, as not unfrequently serious cerebral disturbance depends upon inflammatory conditions of these organs; and when such is the case, the use of alkaline diuretics, as the acetate or the bicarbonate of potash, will be indicated. To relieve pain, dizziness, and restlessness, the bromide and the iodide of potash, with the fluid extract of ergot, may be exhibited with advantage. Cupping over the nape of the neck, followed by a blister, when the attack is more than usually severe, will confer great relief; and the same may be said of an active mercurial purge. A seton inserted into the back of the neck, where the disease proves tedious, in some instances exercises a salutary effect by inviting the blood from the brain and preventing cerebral irritation. Time, after all,

appears to be the great remedy, and, where there is no serious structural alteration of the intracranial contents, it will often work the cure.

Trephining.

Before describing the operation of trephining, it will be proper to formulate or bring together the various conditions which demand a resort to instrumental measures. In general, it may be stated that it is only in cases where the brain-injury is *local* that trephining can promise any benefit. The causes which produce symptoms requiring instrumental perforation of the cranium are all referable to three sources,—bone, blood, and pus.

1. When there is a depressed fracture of the skull, with *persistent* symptoms of compression, the trephine should be used.
2. A compound fracture of the skull, accompanied by symptoms of compression, with or without depressed bone, is a suitable case for operation.
3. In compound fractures with depression, even though no symptoms of compression be present, it will be proper to elevate the depressed portions of bone, provided it can be done by the chisel or lever. The use of the trephine under such circumstances is not allowable.
4. In compound comminuted fractures with depression, whether symptoms of compression exist or not, the skull should be trephined, and the pieces elevated, or, if very loose, removed. If the elevation can be effected without the trephine, the latter should not be used.
5. In punctured fractures, with or without signs of compression, the skull should be trephined.
6. In cases of traumatic epilepsy, where the traces of the injury originating the disease can be recognized upon the cranium, where there are frequently-recurring convulsions, which are not in any way controlled by internal remedies, and where the mental powers are becoming greatly impaired, rendering the patient unable to transact the common business affairs of life or incapable of using the ordinary precautions for self-protection, the use of the trephine is entirely justifiable, and offers the unfortunate sufferer the only prospect of relief.
7. When from three to five days after a compound fracture symptoms of meningitis or encephalitis develop, and when there is reason to believe that these have been produced by a scale or spicule of bone from the inner table pressing against the brain, the use of the trephine will be indicated with a view to remove the osseous splinter, or, in case such spicule should not be present, to give exit to the inflammatory products which sooner or later must destroy life unless removed.
8. In cases of brain-compression, whether from traumatic or other causes, in which there are strong reasons for believing that the symptoms are the result of blood or pus, and where the surgeon is able to locate the offending cause with a reasonable degree of certainty, I can conceive of no good reason why the trephine should not be used.

Operation.—Having summarized the conditions which require a resort to the trephine, it will be proper next to describe the instruments necessary for its proper execution, and their use.

These instruments consist of an ordinary scalpel to incise the scalp and expose the bone, a trephine, a probe with a flat end, a brush for the teeth of the trephine, an elevator, a lenticular, a Hey's or Scultetus saw, a Holsen's chisel, a pair of forceps, a tenaculum, and some ligatures.

There are two trephines in use, the cylindrical and the conical. (Figs. 205, 206.) The instrument is generally made too large. For opening the skull in cases of depressed bone, there is no necessity for having the trephine more than half an inch in diameter (Fig. 207), as the object is merely to cut a hole for the introduction of the elevator. The necessity for two trephines of different diameters exists when operating over the frontal sinuses. The two tables of the skull at this place not being parallel with

each other, it becomes necessary that the outer one shall be cut with the large, and the inner one with the small instrument. It is not a matter of much importance, especially with a careful surgeon, which form of the tre-

FIG. 205.

Cylindrical trephine.

FIG. 206.

Conical trephine.

FIG. 207.

Small-sized trephine.

phine—the cylindrical or the conical—is used. The latter is perhaps the safer instrument of the two, as it is less likely to wound the membranes in completing the perforation of the bone. The trephine is armed with a sharp-pointed centre-pin, which can be slid up and down at the will of the operator and can be fixed by a sliding button on the stem of the instrument. The object of this pin is, by penetrating a short distance into the bone, to act the part of a pivot or axis, around which the saw can move until a groove is cut sufficiently deep to prevent the instrument from slipping, after which it must be drawn within the crown.

FIG. 208.

Ordinary silver probe.

The probe (Fig. 208) is designed to clean out the débris from the track of the trephine, and does not differ from the ordinary silver probe of the

FIG. 209.

Trephine brush.

FIG. 210.

Elevator.

FIG. 211.

Lenticular.

FIG. 212.

Hey's saw.

FIG. 213.

Modified form of Hey's saw.

pocket-case. A quill tooth-pick will answer very well as a substitute. The brush (Fig. 209) is used to clean the bone-dust from the teeth of the trephine

in order that the instrument may cut without obstruction. The elevator (Fig. 210) and the lenticular (Fig. 211) are employed, the first as a lever and the second as a tractor, in raising depressed portions of bone to the proper level. The saws (Figs. 212, 213) are designed to cut, in either a straight or a curved course, portions of bones which have become wedged, and to open a way for the elevator. These saws have a very limited application to injuries of the head.

The chisel of Holsen (Fig. 214) is useful in detaching pieces of comminuted bone, and by means of its lateral prolongation is capable of being

Fig. 214.

Holsen's chisel.

used as an elevator. The scalpel is employed to raise the scalp and expose the bone, the tenaculum to lift any vessel which may require the ligature, and the forceps—an ordinary pair—to remove the circular piece cut by the trephine.

A trephine may be applied at any portion of the skull; but when the case is one admitting of a choice, there are certain portions which should be avoided. These localities are the following: in the course of the superior longitudinal sinus which lies under the antero-posterior median line of the skull; over the occipital protuberance, beneath which rests the torcular Herophili, the point of confluence of several sinuses; over the frontal air-cells, which would expose the patient to the risk of a fistula from the escape of air; and, lastly, over the anterior inferior angle of the parietal bone, at the point of entrance into the skull of the middle meningeal artery. When the location of the injury compels the surgeon to disregard these suggestions, he should exercise the greatest care to avoid inflicting damage upon the exposed blood-channels.

The Operation.—The patient being placed upon a table, with the head resting on a firm pillow covered with oil-cloth, over which should be spread a towel, the hair must be cleanly shaven for some distance around the injured part. If the case is one of complete compression, there will be no necessity for administering an anæsthetic, as the patient will be entirely insensible to the operation. In cases of epilepsy or punctured wounds, demanding the use of the instrument, anæsthetics are not contra-indicated. The next step consists in exposing the bone to be bored and elevated. Should there be an external wound, it may be enlarged in the proper directions; if not, there are two incisions which accomplish this object, the crucial and the horseshoe. (Fig. 215.) The latter I greatly prefer, as by lifting a semicircular flap like the lid of a box, it can be held out of the way by the operator himself. In raising this trap-door the knife should go down at once to the bone. If any considerable vessels are divided, ligatures should be applied. The surgeon at this stage is able to examine the true nature of the injury. Should the fracture be a comminuted one, he may be able to slip the blade of a pair of forceps beneath the edge of a fragment, and gently pull it away; or he may find the depressed piece kept down by the jutting over of a point of the contiguous bone, which will require, for the admission of the elevator, the removal of this angle, to effect which will demand the use of the Hey's saw or the Holsen's chisel. If, however, the depression be in the form of a groove or gutter, the skull must be bored. The periosteum being divided in a circular form to prevent its laceration by the teeth of the saw, the centre-pin should be pushed down, and the instrument planted, not upon the depressed bone, but chiefly

Fig. 215.

The crucial and the horseshoe incision.

upon the undepressed (Fig. 216), allowing it to project over upon the former. After a few movements communicated to the trephine by the hand of the operator carried from pronation to supination, a groove sufficiently deep will be cut to steady the instrument, when the centre-pin must be withdrawn; otherwise, being in advance of the saw, it would plunge into the brain before the bone was cut through. The rotary motion being resumed should be frequently interrupted, the teeth of the trephine cleansed from the bone-dust and blood with the brush, and the progress determined by a most careful exploration of the groove with the flat end of the probe, cleaning out the dust, and noticing particularly any inequalities in the division of the bone. By grasping the circular disk of bone frequently with a pair of forceps, its mobility is easily ascertained. A valuable sign of the progress of the instrument will be seen as soon as the external table is divided and the trephine enters the vascular diploë,—namely, a free flow of blood welling up through the groove. As the cutting advances, the utmost care should be observed: some portions will divide less rapidly than others, and the trephine must be inclined so as to press most upon these points, allowing it to advance chiefly by its own weight, and remembering that the issues of life and death hang upon a few movements of the hand. There is no urgency. The fate of the patient does not depend upon a few minutes of time, and consequently this stage of the operation should be executed with gentleness, deliberation, and patience, by which the surgeon will generally succeed in dividing the last fibres of bone and removing the little circular piece without the trace of a scratch upon the dura mater, a desideratum of transcendent importance to the success of the operation. As soon as the disk of bone is removed, the point of the elevator should be slid beneath the depressed fragment, and, using the sound bone as a fulcrum, should raise it to the proper level.

Fig. 216.

Trap-door flap deflected, and the trephine applied to the skull.

This operation will answer not only for the elevation of depressed bone, but also for the evacuation of blood or pus lying beneath the bone and the dura mater. On no conditions should the latter be wounded or opened, except when there are unmistakable signs of the presence of blood or pus underneath the membrane, as such an opening adds the gravest complication to the case.

Should there be bleeding from a sinus or from one of the meningeal arteries, a little compress with a dossil of lint, retained for a few hours, will usually arrest the flow. The subsequent treatment of the wound consists in replacing the flap without suture and applying the cold-water or ice bag. The opening made in the skull is rarely closed by bony matter, but generally by a fibrous membrane, through which the movements of the brain can be readily felt, and for the protection of which it is advisable to wear a little shield of leather or metal.

INJURIES OF THE FACE.

Anatomical Peculiarities.—The facial region, though greatly exposed, possesses, in the articulation of the head with the summit of the vertebral column and in the ready assistance of the arm under the quick direction of the intelligence, a very effective combination for its defense against all injurious external influences save such as are unexpectedly swift and irresistible. The

facial region has certain anatomical peculiarities, which should always be considered in dealing with the accidents to which it is exposed. Its skeleton consists of thirteen pieces of irregularly-shaped bones, for the most part thin and fragile in their texture and richly supplied with blood-vessels. Some of these bones possess canals for the passage of important arteries and veins, as the inferior dental and infra-orbital; also for the safe passage of nerves, as those belonging to the fifth pair. The integument is not movable over the underlying fascia, but adheres closely to the muscles beneath, by which those lines and depressions are accurately maintained which confer on the face what is called expression. Some of these lines are passive, and belong to the state of repose; others are only brought out under the influence of the different emotions. The muscles are imbedded in soft cushions of fat, the absorption of which, in cases of exhausting disease, communicates the ghastly look to the countenance. The integument is richly supplied with blood-vessels and nerves. The arteries are derived from the external and internal carotids. The external carotid supplies the facial, parotidean, transverse facial, temporal, and internal maxillary; the internal carotid furnishes the frontal and supra-orbital. Most of the arteries are very tortuous or serpentine in their course. The veins empty into the jugular.

The nerves are derived from the fifth and seventh pairs, the former conferring sensation upon the face, and motion to the muscles of mastication through its motor trunk, and the latter imparting motion to the muscles of expression.

In front of the ear, and extending from the zygomatic arch to the neck, lies the parotid gland, its excretory duct, or the duct of Steno, crossing the face to the anterior border of the masseter muscle in the direction of a line drawn from the lobe of the ear to the ala of the nose. The skin is abundantly supplied with sudoriferous and sebaceous glands. The bones which constitute the skeleton of the face are so disposed as to provide chambers for the accommodation of three important organs of special sense, viz., vision, olfaction, and gustation. The region is consequently one very highly organized, and on this account its wounds heal with great rapidity.

Contusions or Unopened Wounds of the Face.—These injuries are often inflicted in pugilistic encounters, though they may result from other causes, and are followed by a dark discoloration and by swelling, in consequence of the extravasated blood. The parts which suffer most from this cause are the eyelids,—hence the common expression of a "black eye,"—which depends upon the delicacy of the skin and its loose connections with the orbicularis palpebrarum muscle permitting the blood to find its way through the parts without difficulty.

Treatment.—In the exercise of what is sometimes called the "manly art," and when the extravasated blood and serum are so profuse as to close the eyelids and interfere with the progress of the "mill," it is a common practice, and a very good one, for the seconds of the ring to make punctures with the point of a lancet, press out the blood, and apply cold water to the parts. In ordinary cases, however, of facial contusions, the proper treatment for the first six or eight hours is to apply compresses wet with cold water and bind them to the parts by a roller, the effect of which is to constringe the vessels and stop all leakage, after which the case may be left to natural processes, or to the use of slightly stimulating applications, such as water mixed with a little alcohol (alcohol, one part; water, ten parts). As the continued use of cold prevents that vascular activity which is necessary to remove the blood, its value is limited to the first few days, after which it should be discontinued. Some remedies are vaunted as possessing a specific influence over these ecchymoses, such as tincture of arnica, linimentum saponis, tincture of hamamelis Virginica, etc., but there is no evidence whatever that they exercise any such power. The rich supply of vessels and lymphatics generally insures a rapid absorption of the foreign matter; and where the individual possesses a good, sound constitution, I believe all local applications are less influential

in the removal of extravasation than is generally supposed. To conceal the discoloration, when quite small, a piece of ordinary adhesive or court plaster is the best application, or it may be touched with a flesh-colored paint.

Constitutional shock, I have noticed, greatly delays the removal of extravasations of blood, whether in the eyelids or in other portions of the face. Patients, for example, who are brought into our hospitals with numerous contusions from railroad collisions, retain the discolorations very much longer than those whose bruises are only local; and if any applications are made in such cases, they should be warm, as well as slightly stimulating. The use of tonics like quinine, with an ample diet, will materially assist in securing the removal of the blood in cases where the general system has been severely shocked.

Open Wounds of the face are produced by sabres, knives, etc., in which case they belong to the incised class; or they may be contused and lacerated, as when inflicted by the conjoined action of a blow upon the mouth and the resistance of teeth behind the lips. Of the same nature are those injuries which are called scratches, such as are made by the nails of man and other animals, or when the face is dragged over gravel or small pebbles. Punctured wounds of the facial region are not unfrequently produced by hooks and by bayonets, and gunshot wounds by balls and other missiles used in warfare.

Treatment.—As in wounds elsewhere, the first indication is to arrest hemorrhage. In consequence of the rich vascular supply, the bleeding in incised wounds of the face is usually for a time quite profuse; but, except when the facial, angular, labial, or lateral nasal arteries are involved, it soon subsides spontaneously. Should the bleeding not cease after exposure to the air or the application of cold water, the vessel or vessels must be searched for and tied with the animal ligature, both ends of the latter being cut off. Second, all foreign matters should be removed from the wound, either by picking them away with the fingers or forceps or by washing by the douche or by a small stream of water from the nozzle of a water-pipe or syringe.

The third indication is the closure of the wound; and this demands more than a passing notice. The utmost care should be observed to place the disjoined parts as nearly as possible in the position which they had before the accident: especially is this imperative when the wound is situated near the angle of the mouth or nose, or when it is near the eyelids or over the eyebrow. A little carelessness on this point may change the whole expression of the face. It is astonishing what an alteration in the facial individuality of a person will follow the mal-adjustment of a wound at the angle of the mouth, below the orbit, or over the eyebrow. A cheerful face may be transformed into one of melancholy, a soft eye into a repulsive stare, and the open and assuring brow into a malign frown, making a face

"fit for treason, stratagem, and spoils."

In several instances I have had occasion to perform operations in order to remedy such defects produced by badly-adjusted wounds. The approximation is best effected by the interrupted suture, using a very fine silk thread, which I prefer to silver wire, the latter not being sufficiently flexible or pliable to prevent the tissues from twisting with the wire. When the cartilage of the eyelid is divided, it is not necessary to insert the stitches deeper than the muscular layer; the addition of a compress and roller will retain the parts more securely. In very slight transverse wounds of the eyelids, the approximation may be maintained with adhesive or skin plaster. Wounds involving only the integument of the nose do not require sutures, as the skin is inextensible, and the exercise of tension will result in ulceration, by which the threads cut quickly out; or it may provoke a diffuse inflammation. When the cartilage is divided, sutures should be employed; but they must not be inserted deeper than the integument.

Wounds of the lips are readily closed by the interrupted suture. When the entire thickness of the lip is divided, pins should be inserted as deep as

the mucous membrane, to control the coronary vessels, and the parts be brought together by the twisted suture. Except in the lips, it is very seldom, however, that I find it necessary to use pins in closing wounds of the face, and when they are employed they should be very slender and delicate. The integument on the posterior surface of the auricle of the ear, when divided, should be closed with the interrupted suture, but such stitches should not include more than the integument, even when the cartilage is involved, though, if the division is extensive, they should be introduced on both surfaces. After the insertion of sutures, the wound may be concealed by a few strips of fine isinglass or skin-plaster. The vascularity of the parts is such that union takes place very quickly, and it is rarely necessary to allow a suture to remain longer than forty-eight hours. In lacerated wounds, however, it will require a longer period; and the only circumstance which should govern the removal of stitches is ulceration. When the threads begin to cut through, they should be removed, and the necessary support given by adhesive and other plasters.

In scratches, the little crusts of blood which form upon the surface constitute the best dressing, and should not be disturbed: by the time these drop off, the reparation beneath will have been completed. The numb, stiff feeling which so generally follows these injuries is best relieved by covering the parts with a little zinc ointment, to which some morphia has been added, in the proportion of one grain of the latter to one drachm of the former.

Gunshot Wounds of the Face.—These wounds are by no means uncommon, and may involve either the soft parts or the bones. The mutilation which sometimes follows these injuries is horrible in the extreme, but the wonderful power and capacity of repair possessed by the parts render these lesions less serious than their appearance would at first indicate.

There is a case related by Guthrie which I never recall but with mingled feelings of pity and admiration. An officer at Badajos had his entire face carried away by a cannon-shot. One eye, though displaced, still remained, by means of which, forgetful of himself, he was enabled to write the thanks which he could not speak for the kindness rendered to him by the attendants.

In the Crimean War, according to Macleod, there were 382 flesh wounds of the face, with only a single death, and 155 penetrating and perforating shot wounds of the bones, with 13 deaths, or a mortality of 8.3 per cent.

The death-rate in the War of the Rebellion, as shown by Dr. Otis, is greater than is usually supposed to attach to such injuries when attended with fracture. In his analysis, wounds of the orbital region are included. The following table* will serve to show the varieties and results of 9815 such wounds:

	Cases.	Duty.	Discharged.	Died.	Unknown.
Sabre and bayonet wounds	64	40	15	2	7
Fractures of bones from various causes	64	37	17	3	7
Injuries of the soft parts	271	167	83	3	18
Gunshot flesh wounds	4914	2396	1310	58	1150
Gunshot, orbital region	1190	379	679	64	68
Gunshot fractures of the bones of the face	3312	1154	1488	340	330
Total	9815	4173	3592	470	1580

As there are 1580 cases in which the termination was not known, it is only fair to estimate the mortality from the remaining 8235, which yields a death-rate of 5.7 for all degrees of injury. Of the 2982 known terminations of facial fractures the death-rate was 11.4 per cent.

The report of M. Chenu on the "Medical Service of the Crimean War"

* Surgical History of the War, Part I. vol. ii. p. 382.

supplies the records of 1414 wounds of the face from various causes, with 184 deaths, or a mortality of 13 per cent.*

In the Italian War of 1859 there were recorded 955 cases of injuries of the face, by the same author, with 114 deaths, or a mortality of 11.9 per cent.†

When considered in their entirety, the mortality of face-injuries is very small,—a result which might be expected when it is remembered that there are no great vessels exposed, that the bones are for the most part small, thin, and porous, and consequently, when perforated, do not furnish extensive splinters, that there are numerous outlets for the products of inflammation, as the mouth, nose, and orbits, and, last and not the least, that, by reason of the rich supply of vessels furnished by the facial and internal maxillary arteries, it is only with great difficulty that the vitality of the bones can be destroyed.

Treatment.—Wounds involving only the soft parts, whether incised, punctured, contused, or lacerated, demand no treatment different from that appropriate to similar wounds from other causes, but when they are made by the passage of a ball the suture is generally dispensed with. Sloughing to some extent will follow in the track of the missile, and hence all attempts at quick closure will prove futile. The practice of paring away the contused edges of such wounds, thus converting them into incised ones, and then uniting by stitches, at one time advocated by Larrey, and recently tested by medical officers in the Confederate army, is of very doubtful propriety. After arresting hemorrhage by the ligature should any vessels require a thread, and removing any foreign matter, it will be proper to apply simply a pledget of lint or linen wet with cool water and secured by a roller or a strip of adhesive plaster, renewing it as often as it becomes dry. Partially detached, distorted, or torn tissues should be pressed into position, and never cut away unless suspended by a very slender bond. When the soft parts are severed in such a way as to form ragged and displaced flaps, the introduction of metallic sutures will be necessary, as a means of retaining the parts in position until the detachment of the sloughs, or until the tendency to displacement is passed. Adhesive plasters can sometimes be used with the same object.

When balls penetrate the bones of the face, they may be wedged in between broken fragments, either in the frontal, maxillary, or ethmoid sinuses, or they may pass into the mouth, nose, or orbit. A careful exploration with the probe should be made in order to localize the missile, which should be extracted if possible. The same care is to be observed in reference to the management of fragments of bone as in the adjustment of the soft tissues: they should be pressed into position, and only removed when their connection with the surrounding parts is so slight as to leave no hope of their vitality being maintained.

The constitutional treatment consists in restricting the diet for two or three days, keeping the bowels in a soluble condition by a saline cathartic, and when pain is experienced administering opiates in doses sufficient to furnish relief.

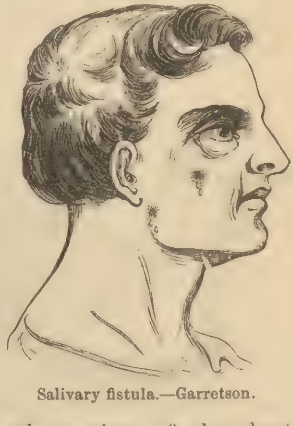
Secondary effects.—Hemorrhage is often not only a troublesome but also a very serious complication of gunshot injuries of the face. It is not usually difficult to control when primary or at the time of the accident. The use of cold and the ligature, or the application of a tampon, with compression, is generally quite sufficient for this purpose. It is the secondary hemorrhages that prove so annoying and add such gravity to these cases: this bleeding may occur at any period from the fifth to the twenty-fifth day. If not controlled by the tampon and pressure, and if the vessel from which the blood escapes cannot be discovered and tied, there remains but one alternative, namely, ligature of the carotid. Styptics are useless, and some of them, such as Monsel's preparation of iron, are filthy as well as inefficient. The reports furnished from the office of the Surgeon-General, and analyzed by Dr. Otis, show fifty-two cases of ligature of the primitive carotid, and two of

* Surgical History of the War, Part I. vol. ii. p. 383. † Ibid., p. 383.

the external carotid, for hemorrhage consequent upon gunshot wounds of the face. The result was ascertained in all but a single instance, recovery following in fifteen cases, and death in thirty-eight, or 71.7 per cent. With the exception of two cases, which were wounds of the soft parts, all the rest requiring the ligature were connected with fractures located most frequently in the lower jaw (twenty-three cases), next in the upper jaw (twenty-two cases), and lastly in the malar and mastoid regions (nine cases). In four cases the artery was ligated a second time: of these one recovered. The success of ligature is not very flattering; but fifteen successes out of fifty-two will compare favorably with the results in amputation of the thigh at the upper third. The obstinacy with which some of these deep-seated vessels bleed is to be referred not only to the inflammatory changes which follow facial injuries, but also to the fact that on account of lying wholly or in part in bony canals they are prevented from contracting. A very remarkable case of obstinate hemorrhage occurred in the Pennsylvania Hospital under the care of Dr. Morton, in which the spheno-palatine vessel was wounded by a piece of glass penetrating the parts between the lip and the anterior nares. So intractable did the bleeding prove that the carotid was tied; but, while this proved effectual for the time, the patient subsequently died from hemorrhage the result of ulceration of the internal jugular.

Salivary Fistula.—Salivary fistula, as a result of face-injuries, is frequently encountered, both in civil and in military practice. It may involve either the salivary glands or their ducts. The duct of Steno is most commonly implicated, though that of the submaxillary and those of the sublingual do not escape. Salivary fistula is caused by wounds of the cheek, by ulceration following salivation, and by the extraction of teeth, the alveolus being broken and the accident being followed by inflammatory closure of the excretory canal, and abscess which opens upon the external surface of the cheek. The abscesses which follow low fevers may open a few lobules of a salivary gland and give rise to a fistula. Bryant speaks of such.* I once saw a case of congenital salivary fistula in which the opening was on the anterior part of the helix of the auricular cartilage. The obstruction of the Stenonian duct by the presence of a salivary calculus sometimes causes a fistula. When it arises from this cause it will be preceded by a soft, fluctuating swelling in the line of the duct. The opening, when the duct of Steno remains free, is usually just below the malar bone (Fig. 217), and is surrounded with a red or purple color, with depression of the soft parts. I have known the disease confounded with necrosis of the upper jaw, which is occasionally associated with the affection, and indeed myself committed this blunder on one occasion. The discharge which flows from the fistulous orifice will indicate the true nature of the affection. It is thin and watery; whereas in caries or necrosis it is purulent. Dr. Garretson† mentions a variety of salivary fistula in which, by the subcutaneous ulceration of a few lobules, the secretion escapes, and by burrowing in the tissues of the face forms a cyst, the opening of which may be remote from the duct. In a case of sublingual fistula which came under his observation, the cyst formed in front of the hyoid bone.

Fig. 217.



Salivary fistula.—Garretson.

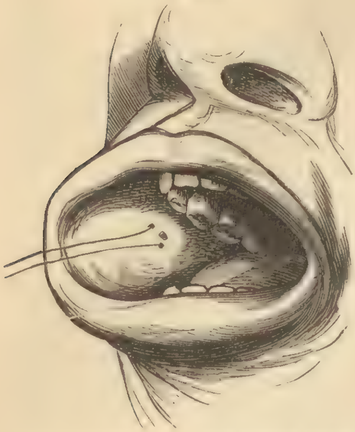
Treatment.—The treatment of salivary fistula is often attended with indifferent success. When the fistula is situated upon the cheek, the internal opening of the duct of Steno should be carefully sought for, and graduated probes inserted, dilating its orifice until no obstacle is offered to the escape of the secre-

* Surgery, p. 243.

† System of Oral Surgery, p. 509, 2d edit.

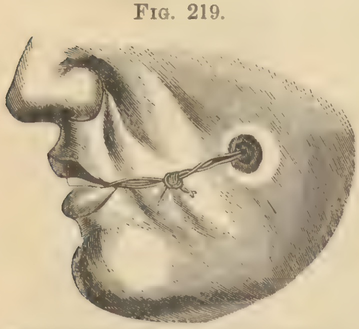
tion into the mouth. At the same time the external opening on the face should be cauterized with nitrate of silver, or the galvano-cautery when convenient, and immediately covered with gauze and collodion, or the rubber plaster. The dilatation should be repeated every day or two. Cases are occasionally cured after this manner. It was the plan pursued with success in the few instances of salivary fistula which occurred during the War of the Rebellion. The same treatment will succeed in small fistulæ communicating directly with a few lobules of the gland. Many cases, however, will be encountered in which we are obliged to resort to other methods. That which in my judgment will be found to yield the most satisfactory result, is first to find the opening at the end of the Stenonian or parotid duct, on the inside of the cheek, and, if possible, insert a fine silver probe, then, taking one or two silk threads, pass the same by means of a needle between the external surface of the cheek and the duct, some distance above the opening of the latter. The ends of the thread, being brought out at the corner of the mouth, should be secured with a piece of adhesive plaster to the cheek. In making the internal punctures the operator should be careful not to transfix the duct, but to pass beneath it so as to isolate it as much as possible from the cheek. (Fig. 218.) The probe, if lodged in the excretory canal, will materially assist in effecting this important feature of the operation. The external opening, or that on the cheek, should, after three or four days, be touched with nitrate of silver, and covered with a piece of adhesive plaster or gauze and collodion. The threads serve to convey the salivary secretion into the mouth, and thus allow the external opening to heal. As soon as the saliva shows no tendency to discharge externally, the seton may be removed, should it not have already ulcerated through. The seton has been employed after another fashion, by passing a few threads of silk through the eye of a fine probe and conducting them through the fistula and the duct into the mouth, then securing together the ends of the threads which lie respectively on the cheek and within the mouth. (Fig. 219.) In about two weeks, should this plan prove successful, the saliva will drain into the mouth, after which the threads should be taken out, when the opening on the cheek will close up spontaneously, or may be treated by the cautery, in order to excite healthy granulation and cicatrization. The operation of Prof. W. Horner consisted in excising a round portion of the cheek, including the fistulous track, with a shoemaker's punch, counter-pressure being made by a wooden spatula placed inside of the mouth. The external wound was closed by sutures.

Fig. 218.



Author's method of treating salivary fistula. The cheek is represented as everted, showing the orifice of the duct of Steno, and the seton deposited between the duct and the outside of the cheek, with its two ends brought out at the corner of the mouth. As the threads cut their way out by ulceration, the duct is detached from the external opening in the cheek.

Fig. 219.



Seton for salivary fistula of the parotid duct.

Dr. Garretson has met with encouraging success in the treatment of salivary fistula of the parotid duct by first making an incision through the fistulous track in the cheek, and then introducing a pyramidal cotton tent, the base presenting to the mouth and the apex to the outside of the cheek: this is retained in posi-

tion by a slender thread fastened to its summit, and is secured to the skin with adhesive plaster. This tent is subsequently replaced with a wire seton, made by doubling fine silver wire on itself several times, so as to occupy one-half the thickness of the cheek, a single thread of the same wire being continued through the outer half to the surface of the face. This wire seton is kept in position by clamping a grain of shot on each extremity. The surgeon who has much to do with these fistulæ will be compelled to vary his plans to meet particular cases, and need feel no disappointment if he is obliged to repeat the operation perhaps several times before he is successful.

In cases where there is much loss of substance it will often be necessary to resort to plastic processes to close such openings.

The loss of the lower lip, or the destruction of submental portions of the face, will give rise to a dribbling of saliva, which is vastly more detrimental to health than a salivary fistula, as it tends not only to impair the digestion, but also, by the drain, to enfeeble the general strength.

An interesting case, of a colored boy, was treated by Dr. Hunter at the University Hospital, in which the entire chin, including the middle of the lower jaw, and all the soft parts down to the hyoid bone, had been carried away by a gunshot accident, leaving the tongue protruding into the chasm. After the parts had cicatrized, a plastic operation was executed, which succeeded in restoring the lip, with the mental and submental regions, so perfectly that the saliva, which before had kept the patient's clothing drenched, could be perfectly retained.

Necrosis constitutes another of the after-effects of face-injuries, though the bones, in consequence of their high vitality, are not particularly prone to this disease as a result of traumatism, unless some constitutional vice is called into activity. If a ball is lodged in the nasal or maxillary cavities, it will after a time excite inflammatory disease of the bone; and in all cases where a shot-injury has been received in the face, an exploration should be instituted with a view to determine the presence of the missile, and, if found, its removal, if practicable, should be promptly effected. Whenever any diseased portions of the bones of the face become loose, they should be pulled away with as little division of the soft parts as possible.

Neuralgia.—In consequence of inflammatory thickening of one of the trunks of the fifth nerve, or of its sheath, or in consequence of an injury to the bony canal in which it is placed, subjecting it to pressure, very distressing attacks of neuralgia are developed. Unlike those forms which arise from cold and miasmatic excitants, or from reflex influences, such as a decayed tooth, internal treatment avails little; but it should never be omitted before advising an operation. I can recall instances of a very unpromising kind, and where an operation had been urged upon the patient, which nevertheless recovered under the use of iodide of potash, arsenic, and quinine. When constitutional remedies fail, then a resort to resection of the nerve at fault becomes proper. The three branches of the fifth or trifacial nerve which have been the subject of such operations are the ophthalmic, superior maxillary, and inferior maxillary. Great credit is due to Carnochan, of New York, who may be said to have been the first to demonstrate the feasibility and value of such sections, and whose results have been verified by numerous operators since.

When the supra-orbital branches of the ophthalmic nerve have been injured, giving rise to neuralgia of the brow and certain parts of the scalp, the accompanying artery becomes distended and pulsates strongly, and the parts in the course of the nerve-distribution are excessively tender. This tenderness is greatest when the pressure with the finger is light; firm pressure over the nerve where it issues from the supra-orbital foramen will afford relief. The attacks of pain will frequently be alleviated or cured temporarily by rubbing over the parts an ointment consisting of five grains of veratria

and one drachm of simple cerate, or a hypodermic injection in the course of the nerve of one-quarter of a grain of morphia. After the attack the patient should be placed upon a course of quinine, arsenic, and iron. This plan of treatment failing, the trunk of the nerve where it emerges from the supra-orbital foramen should be exposed, and a portion excised. It is proper to state, however, that this operation, while it almost certainly gives temporary relief, does not always effect a radical cure, the disease often returning with the original intensity.

Where the disease involves the superior maxillary nerve, the pain is experienced in the soft parts of the cheek, and should it prove rebellious to the usual therapeutic measures appropriate to neuralgia, the only alternative is excision of the nerve.

The operation of Carnochan consisted in dividing the nerve posterior to Meckel's ganglion in front of the foramen rotundum. The point for division must be determined by the extent and location of the pain. The nerve after it leaves the ganglion of Gasser gives off branches in the spheno-maxillary fossa, which supply the temple and side of the forehead, the molar and bicuspid teeth, the corresponding portion of the gums, and the lining of the antrum. If the pain is experienced in these localities, the division, to be effectual, should be made in front of the foramen rotundum. I must, however, qualify this statement somewhat by saying that it is possible that the nerves which supply the regions just named, namely, the temporal, malar, and posterior dental, may suffer from the reflex influence of a cause anterior to their origin, in which case a division of the nerve in the infra-orbital foramen will serve to cure the pain in the localities referred to. I know not how this is to be determined with any certainty; but we may approximate its solution by the degree of suffering referred to these regions of distribution as compared with those on the cheek and front of the jaw.

After the nerve enters the infra-orbital canal, and just before its escape from the infra-orbital foramen, it gives off the anterior dental, which supplies the incisor, canine, and first bicuspid teeth, and the mucous membrane about the front of the nares. After the nerve emerges from the infra-orbital foramen and reaches the face, the palpebral, nasal, and labial branches are supplied. Should neuralgic disease of the superior maxillary nerve resist the ordinary constitutional remedies, and the suffering prove so intense as to warrant surgical interference, we must plan our operation upon the relative degree of local pain. If this be experienced chiefly in the upper part of the face, side of the nose, lower eyelid, and incisor and canine teeth, we may reasonably infer that we have to deal only with that part of the superior maxillary nerve in the infra-orbital canal; but if the chief distress is felt in the molar teeth and temporal region, then no operation which does not include the spheno-maxillary portion of the nerve will prove of avail. To excise the nerve in the infra-orbital canal there are two routes of access, one by cutting away the floor of the orbit, the other by raising its periosteum and attacking the nerve in the groove formed in the bone. The latter I find entirely feasible and requiring but little time for its execution. An incision one inch and a half in length should be made one-quarter of an inch below and parallel with the infra-orbital ridge down to the bone, the upper flap dissected as far up as the orbit, and the loose fatty tissue between the floor of the orbit and the ball of the eye pushed upwards. If a director be pressed firmly upon the orbital surface of the floor at different points, one will be touched where the periosteum sinks or can be depressed: this indicates the location of the groove in which the trunk of the nerve rests, and is external to the middle of the floor. The periosteum, which forms the upper wall of the canal, should be divided, when the nerve will be brought to view, and, being raised with a blunt tenaculum, can be excised with a pair of scissors.

In the operation of attacking the nerve below the orbit, a semi-lunar incision should be made below the eye, its extremities resting on the inner and outer portions of the infra-orbital ridge. The flap being raised and turned

over the eye, the crown of a trephine is next applied over the infra-orbital foramen of the upper maxillary bone, including the infra-orbital ridge, and by a few rotary movements the anterior wall of the antrum is removed. After a few touches with a delicate chisel to the floor of the orbit, the nerve will be exposed, and can be cut out. Should it be desirable to excise the upper maxillary nerve in the spheno-maxillary fossa, or behind the ganglion of Meckel, two trephines will be required,—a large one to remove the front wall of the maxillary sinus, and a smaller one to cut away the posterior wall. The floor of the orbit corresponding to the course of the nerve is next removed with a chisel and bone-pliers. This gives free access to the spheno-maxillary fossa, when the nerve may be followed back to the foramen rotundum, close to which it should be divided and a portion excised. The bleeding which accompanies this operation is easily controlled by inserting a tampon of lint, should it not cease spontaneously.

Langenbeck has originated a plan of dividing the superior maxillary nerve in the spheno-maxillary fossa by carrying a long tenotome beneath the external palpebral ligament, along the outer wall of the orbit, into the spheno-maxillary fissure. The edge of the knife is then turned inwards, and, as the handle is depressed, is made to divide the nerve before it enters the canal beneath the orbit. The infra-orbital nerve is next exposed by a vertical incision below the lower margin of the orbit, and, being seized with a pair of forceps, is pulled out of its canal.

In unyielding cases of neuralgia affecting the teeth and the soft parts over the lower jaw, it will be proper to excise a portion of the inferior maxillary nerve. This nerve enters the posterior dental foramen, passes through the dental canal in the inferior maxillary bone, in company with the inferior dental artery, supplies the lower teeth and gums, and sends a branch through the anterior mental foramen, which is distributed to the soft parts over the lower part of the face.

Operation.—In excising the inferior dental nerve, I make a horseshoe flap over the ramus of the jaw and masseter muscle, convex downwards, one inch and three-quarters in its vertical extent, reaching almost to the base of the jaw, and one inch and a half in its transverse diameter. (Fig. 220.) This flap is then raised upwards, exposing the ramus, the external wall of which must next be cut out with a trephine, applied half an inch above its angle and about five-eighths of an inch behind the last molar tooth.

Fig. 220.

Author's incision for exposing the inferior dental nerve.

The nerve, which will be exposed with its accompanying artery in the inferior dental canal, should be removed to the full extent of the opening made by the trephine. The bleeding which follows the division of the artery will sometimes prove obstinate: in one case I was compelled to apply the actual cautery; though usually compression or a plug of soft wood forced into the orifice of the canal for twelve hours will be all that is necessary. The wound in the soft parts should be adjusted with two or three interrupted sutures and treated as though it were an ordinary incision.

Dr. Garretson prefers to make an incision along the base of the jaw from its angle, turning up the flap and exposing the body of the inferior maxillary from the ramus two inches forward. With a Hey's saw he next makes two longitudinal cuts, half an inch apart, through the outer wall of the bone into its cancelli, and with a delicate chisel and hammer cuts the included portion away until the nerve is exposed in its canal, after which

it is thoroughly removed. I have seen the doctor practice this method, and was favorably impressed with its efficiency.

Professor Joseph Pancoast has devised a new route by which to reach either the superior or the inferior maxillary nerve by way of the zygomatic fossa. Two vertical incisions are made over the ramus of the jaw, the anterior one extending from the malar, and the posterior from the zygoma, almost to the base of the jaw, taking care not to wound the duct of Steno. (Fig. 221.) These two vertical cuts are next joined at their lower extremities by one which is transverse. The masseter being exposed is then detached from the bone, and, together with the other soft parts, turned over towards the temple. The coronoid process is now sawed off and disconnected from the tendon of the temporal muscle, the latter being pushed up into the temporal space. The spheno-maxillary fissure is thus exposed, and the internal maxillary artery, by picking away some loose fat and cellular tissue, can be recognized, and should be tied. The next step consists in separating the superior origin of the external pterygoid muscle from the ridge on the sphenoid bone. If it is contemplated to resect the superior maxillary nerve, the deep part of the wound must be enlarged upwards and inwards towards the apex of the orbit, and as soon as the nerve can be recognized it is to be embraced by a ligature carried around its trunk by means of an instrument curved like an aneurismal needle. The ligature being made fast, the nerve is divided by a knife in front of the foramen rotundum and close to the floor of the orbit. This operation, not difficult of performance in the hands of this distinguished surgeon, is too complex, and involves an accuracy of anatomical detail which will perhaps prevent its being generally adopted.

Fig. 221.

Professor Pancoast's operation for facial neuralgia.

Facial Paralysis may follow a gunshot wound, involving directly the trunk of the facial or portio dura nerve, or indirectly by inflammatory deposit. I have seen it follow a blow delivered at the root of the ear, causing inflammatory infiltration of the parts behind the parotid gland. When the nerve is divided, the case is hopeless. When it is only compressed by plastic exudation, a favorable prognosis may be formed, as the removal of the lymph will be followed by a return of muscular power in the face. The appropriate treatment in such cases will be the internal use of iodide of potash with bichloride of mercury, and the occasional application of a blister over the mastoid portion of the temporal bone.

Lachrymal fistula, a not unfrequent sequel of face-injuries, will be noticed under the head of diseases of the eye.

Deformities, consequent on loss of substance, vicious cicatrices, and sloughing, are subjects upon which no special rules can be laid down, and must be managed after the general principles given under the head of plastic surgery.

WOUNDS OF THE NECK.

Wounds of the neck may be incised, contused, lacerated, punctured, and gunshot. They may be self-inflicted, suicidal; they may be made with murderous intent, homicidal; or they may be accidental.

Wounds of the neck may be classified after the surgical divisions of this region,—that is, into wounds of the middle, lateral, and posterior cervical regions.

Wounds of the Middle Cervical Region.—This region is occupied chiefly by the larynx and trachea, behind which are situated the pharynx and the œsophagus. The thyroid gland rests on either side and in front of the upper part of the trachea, immediately below the cricoid cartilage. On each side are situated the carotid arteries and the internal jugular veins. The anterior jugular veins lie along the inner borders of the sterno-cleido-mastoid muscles. At the point where the trachea passes beneath the sternum it is touched at the right anterior and outer side by the innominate artery, and has in front the innominate vein of the left side. The crico-thyroid arteries run across the membranous space between the cricoid and thyroid cartilages; the superior thyroids descend by the sides of the thyroid cartilage to the thyroid body; and the inferior thyroids, and occasionally the middle thyroid, are in close relation with the trachea, as they are distributed by their branches to the lower portion of the thyroid gland.

Wounds of this region are termed superficial, or deep, according as they are above or below the deep fascia of the neck. When suicidal, the knife, inasmuch as most persons are right-handed, is drawn from left to right, and for the same reason the wound is often higher on the left than on the right side. Such injuries are not necessarily confined to the front of the neck, but often extend into the lateral regions. When inflicted with a view to self-destruction, the act is generally committed under great mental depression, maniacal excitement, or delirium, and the implement employed is usually a razor or knife; even penknives are sometimes used for this purpose. The wound may be situated at any point from the chin to the sternum. These injuries become serious when they penetrate the air- or food-passages, or when they implicate large vessels. If the incision is made above the hyoid bone sufficiently deep, it will enter the mouth, and may divide the muscular connections of the tongue, or even the tongue itself, allowing it to be drawn back over the larynx and produce suffocation. When below the hyoid bone, between the latter and the thyroid cartilage, the epiglottis cartilage may be cut and topple over into the larynx. Should the crico-thyroid membrane be incised, the cavity of the larynx will be opened; and when the wound is made below the cricoid cartilage the trachea is liable to be penetrated. Sometimes the injury is inflicted with a desperation which carries the vulnerating body entirely through the larynx or trachea, and may even sever the pharynx or the œsophagus.

Mr. Durham, in one hundred and fifty-eight cases of cut-throat wounds, found the location to be as follows:

Situation of the Wound.	Number of Cases.
Above the hyoid bone	11
Through the thyro-hyoid membrane	45
Through the thyroid cartilage	35
Through the crico-thyroid membrane or cricoid cartilage	26
Into the trachea	41

Homicidal wounds on the front of the neck are occasionally made with a view to turn popular suspicion from the perpetrator and give the murder the semblance of having been self-inflicted. I know of no means of establishing a distinction drawn from external appearances. It is said that when suicidal the wound is likely to be oblique, and more extensive on the left than on the right side, because usually the knife is held in the right hand; but my experience does not sustain this observation. Importance is also attached to the depth of the wound, suicides not generally cutting, it is alleged, as deep as homicides: yet I have seen the former entirely sever both trachea and œsophagus. The incisions made by suicides are said to be irregular, and often multiple; but those made by homicides, especially if there has been a struggle, often partake of this character.

Prognosis.—Wounds which do not penetrate the mouth, larynx, or œsophagus, or which do not involve vessels below the deep fascia, though not entirely free from danger, usually do well; but when deep, and implicating the

above structures, the complications are so numerous that all such injuries should be regarded as very serious in their nature. These complications are the following:

1. *Hemorrhage.*—When a large vessel is divided, as the carotid artery or the internal jugular vein, death follows in a few minutes. In the case of a man who divided his carotid while in a state of mania a potu, death did not follow for several hours after the infliction of the wound. The act was committed with a dull knife, which no doubt lacerated the artery and may have prevented the fatal gush of blood usual after such wounds. It is rather uncommon for the great vessels to be reached in these attempts at self-destruction, the prominence of the laryngeal apparatus no doubt constituting their protection. An ingenious explanation is given by Mr. Hilton, who thinks that when the air-tube is opened below the glottis, the sudden rush of air from the lungs, and the consequent contraction of the walls of the chest, deprive the thoracico-humeral muscles of their fixed support, and the arm drops. If this be true, it is a beautiful illustration of that marvelous conservatism which is found existing in every part of the body, and which, like a sleepless sentinel, is not inoperative even when a man raises his hand against his own life. I doubt very much, however, if this be the true explanation of the immunity enjoyed by these large vessels. The acute pain produced by the edge of the knife makes the would-be suicide shrink from his purpose, and awakens him to a consciousness of the fearful nature of the act which he is about to perpetrate. Man dreads nothing so much as pain, and I am convinced, from what I have been able to elicit from those who have made ineffectual attempts to destroy their lives, that this explains the depth of cut-throat wounds. Such persons rarely make a second attempt. Death may ensue from wounds of the thyroid, the lingual, or even the crico-thyroid arteries, should the blood pass into the air-passages, producing asphyxia. The latter may be produced by the falling into the larynx of a partially-divided cartilage, as the epiglottis or the arytenoid.

2. *Emphysema.*—When the wound penetrates the larynx or trachea obliquely, so that the opening through the integument does not correspond with that through the air-tube, the air may extend either subcutaneously or beneath the mucous membrane, in the first position permeating the soft parts of the neck and the thorax, and, should it enter the loose tracheal fascia, reaching to the mediastinum; and in the last encroaching so much upon the cavity of the larynx as to produce asphyxia. I once saw a patient die from embarrassed respiration caused by pressure upon the phrenic nerves by an emphysema of the neck and chest. This is the explanation given by Hilton for death under similar conditions.

3. *Entrance of air into veins.*—The admission of air into a vein has, in rare instances, proved a cause of death. Partial division of a vein exposes a person to such an accident more than does a complete section.

4. *Dysphagia.*—Inability to swallow may result from two conditions,—from a wound of the œsophagus, by which solids and fluids can escape into the neck, or from some injury to the spinal accessory or glosso-pharyngeal nerves, by which the complex co-operation of the faucial and constrictor muscles concerned in deglutition is destroyed or rendered imperfect, and which may allow the substances taken into the mouth to pass into the larynx or to be rejected.

Nor are the dangers of such wounds confined to the time of the accident. They may be postponed to a later period, and manifest themselves by inflammatory conditions, such as purulent infiltration of the loose tissues about the larynx and trachea, œdema of the glottis, and broncho-pneumonia. The latter has been the cause of death in most of the fatal cases which have come under my care, where the patient did not immediately perish; and it is just as likely to follow when the injury is above the hyoid bone as when it involves the vocal and respiratory tubes. I lost a case from this cause, which was under my care in the surgical ward of the Pennsylvania Hospital. A horrible gash had been made between the jaw and the hyoid bone, which

extended nearly from one angle to the other of the lower jaw, opening the mouth, and dividing the genio-hyoid, genio-hyoglossi, and portions of the hyo-glossi muscles. Even after an escape from the dangers just enumerated, there are complications which may retard recovery, such as exuberant granulations from the surface of the wound encroaching upon the calibre of the air-tube and obstructing the respiration, or fistulous openings affecting or destroying the voice.

Wounds of the Lateral Region of the Neck are generally either accidental or homicidal, and are for the most part inflicted by knives or balls. The vessels which are exposed to danger are the carotid, superior thyroid, lingual, occipital, facial, internal and external subclavian, vertebral, transversalis colli, and inferior thyroid arteries; the external and internal jugular, the subclavian, and the innominate veins. I remember a distressing case, in which a little girl, the niece of a prominent physician of this city, perished in a few moments, by falling upon a pitcher, in which she was carrying some water to her uncle. A fragment of the vessel was driven into the neck above the clavicle, penetrating the subclavian artery. Bryant relates a case of Mr. Berkett's,* in which death was produced very much in the same way, by a fragment of a broken chamber-vessel wounding the internal jugular of a child. Wounds of this region, when inflicted near the root of the neck, may open the chest by penetrating the pleural sac. The brachial plexus, phrenic, and pneumogastric nerves are likewise exposed to injury. Professor Gross mentions a case in which the brachial plexus, or one of its branches, was injured. The man lost the power of the right upper extremity, which was followed by great wasting of the part, and by severe pain, which involved the arm to the ends of the fingers. Not long since, I was consulted by a gentleman from the Southwest, who had been assaulted in the street of his native town. Both the brachial nerves and the subclavian artery had been damaged, and there was not only partial paralysis of the arm, but also an aneurismal swelling above the clavicle. As the respiratory movements of the diaphragm depend upon the phrenic nerves, any wound of these must prove mortal. The brachial plexus occasionally contributes a filament to the phrenic nerve which passes into the thorax over the third part of the subclavian artery. I have in my possession a preparation in which the entire phrenic follows this course, so that the nerve might be damaged at a point where it would scarcely be suspected. Bransby Cooper lost a patient from spasms of the diaphragm by just such an anomaly, in a case where the subclavian was ligated. Wounds of the pneumogastric nerves are fatal from the interruption of those centripetal influences which excite respiration. Where the nerve on one side only is involved, recovery is not impossible: at least the cases related by the late Dr. John H. B. McClellan and by Billroth favor such a conclusion.

Wounds of the Posterior Region of the Neck, when confined to the soft parts, are much less important than those in front and on the side. As there are no great vessels or nerves, the danger from hemorrhage and paralysis is avoided. Should the injury penetrate very deep, especially at the base of the skull, it may prove rapidly fatal, or produce paralysis by wounding the spinal cord. The exposed condition of the contents of the spinal canal in this region is due to the horizontal direction of the spinous processes, by which vulnerable spaces are left between. The popular notion that posterior cervical wounds are followed by sexual impotence must be founded on cases of injury to the cord or its membranes. The testimony of Lecouest, who had abundant opportunities for observation on this point during the conflicts of the French with the Turks, gives no countenance to this opinion. Should the spinal canal be penetrated and the membranes of the cord wounded, the escape of the cerebro-spinal fluid would indicate the nature of the accident.

* Transactions of London Pathological Society, 1857.

Treatment.—The first duty of the surgeon is to arrest hemorrhage, in whatever region the wound may be situated. Until provided with the necessary means for ligation, a finger or fingers should be thrust into the wound to stay the flow of blood, or, if the bleeding is arterial and from the upper part of the neck, the primitive carotid may be temporarily compressed against the transverse processes of the cervical vertebræ. To attain free access to the wounded trunk, it will sometimes be necessary to clear away the extravasated blood-clots and enlarge the wound in the direction of the vessel. When the internal or external carotid is involved, it is better to tie the primitive trunk; and the same course should be adopted in cases where the bleeding comes from even smaller branches, provided it is persistent and the vessel cannot be located or can only be reached by a tedious division of structure. Should the hemorrhage come from the external jugular, the vein may be compressed or ligated; if from the internal, the vessel should be encircled with a ligature. In cases where the jugular or other large venous trunks are punctured or slit, the safest plan is to tie both above and below the wound, instead of closing the orifice as one would secure an opening in a bag, namely, by raising the edges with a pair of forceps or tenaculum and tying a thread about the fold. The risk of ligating large veins has been over-estimated. A very interesting and exhaustive paper has been written by the younger Gross* on wounds of the internal jugular, which ably illustrates this statement. I once tied successfully the internal jugular of a child not quite a year old, three-quarters of an hour after it had been divided by its mother, who, under a temporary aberration of mind arising from extreme want, cut the throats of her two children and of herself. Her own wound and that of one child proved suddenly fatal. The other child, which I pulled out from beneath the bed-clothing, and which I had supposed dead, until I noticed some blood begin to flow from the wound, was rescued by securing the internal jugular vein, which had been slit. The syncope following the first gush of blood, and the imperfect expansion of the chest, no doubt had arrested the hemorrhage. In punctured wounds of the internal jugular, or where the source of the bleeding cannot be definitely determined, compression, by pellets of patent lint forced into the opening and made secure by a compress, roller, or adhesive strips, should be first employed. In cut-throat wounds, another matter of great importance is to ascertain if there be any clots of blood in the air-passages, and, if so, to effect their removal with the greatest dispatch. Patients have perished from suffocation by a neglect of this precaution. The fingers should explore the pharynx and upper part of the larynx, dislodging any such clots; and if lower down in the larynx or trachea, they must be removed by forcibly compressing the chest, while the head is allowed to hang over the edge of a bed or table. With the same object in view, the air-passage may be assisted with the common injection syringe, when nothing better is at hand; and if the case is urgent, and no instrumental means are accessible, by sucking out the blood with the mouth applied to the opening. When the wound is situated above the hyoid bone, and the anterior attachments of the tongue are divided, allowing extreme retraction of the organ, another danger to respiration arises from the resulting obstruction at the entrance to the larynx. In such a case the organ must be drawn forward, and, if necessary, so maintained by a silver suture passing between its under surface and the hyoid bone. If the epiglottis is partially divided and falls over the glottis, it is best to remove it entirely out of the way.

Hemorrhage being arrested, the next duty is the approximation of the wound. When superficial and in the middle or anterior region of the neck, it may be closed by the interrupted suture; but when deep, and penetrating the air-tube, all such sutures are useless, and sometimes dangerous. Quick union is not to be expected. The escape of air and mucus, the movements of the air-tube in respiration, and, when the wound is high up and opening into the

* American Journal of the Medical Sciences for January, 1867.

mouth, the escape of saliva, combine to prevent the rapid healing of the parts. Should there be much oozing of blood, stitches will prevent its escape externally, compelling it to flow into the trachea; and if there be inflammatory or other swelling about the glottis, the opening below becomes necessary for the purpose of respiration. It is only in cases where the trachea or larynx is entirely divided, or where, in consequence of several cuts in different directions, portions of cartilage become displaced, that sutures should be introduced; and when inserted, they should never touch the mucous membrane, as their presence would provoke a spasmodic cough calculated to prevent healing. The best adjustment, save in these exceptional instances, is that by position. Two or three pillows being placed under the shoulders, the head should be depressed towards the chest just sufficiently to bring the sides of the wound in contact. If it be depressed too much, the edges will overlap; if not enough, they will gape. To maintain the head in the proper place, it may be covered with a night-cap, to each side of which is sewed a strip of muslin long enough to be fastened to a band of the same material passing round the chest; or the occipito-sternal handkerchief of Mayor (Fig. 222) may be used, and made secure by placing a night-cap upon the head.

Fig. 222.

Occipito-sternal handkerchief for approximating a cut-throat wound.

When the pharynx or œsophagus is wounded to any extent, the food will escape during deglutition into the neck, or may find its way into the posterior mediastinum. If the œsophagus be severed, the ends should be united with sutures; but when only partially divided, this will not be required. In all cases of wounds of the pharynx or œsophagus, the patient must be nourished by concentrated broths, milk, and brandy conveyed to the stomach, morning and evening, through a gum tube passed through the mouth to a point beyond the wound. On no account should the patient be allowed to swallow, except by this method. This treatment will be equally proper in cases where the pharynx or œsophagus is wounded from within outwards, as I have known to occur during attempts to pass an instrument through a stricture of the tube. Cases will occasionally be encountered in which the mental condition is such that it is impossible to secure the co-operation of the patient in the introduction of aliment into the stomach by instrumental measures. The person may be maniacal or sullenly resistant. Under these circumstances a resort to ether or chloroform will be proper, or the patient may be sustained for a few days by nutritious enemata until intelligence is restored. When, from delirium, attempts are made to tear off the dressings, it will be necessary to resort to the strait-jacket. Cut-throat cases demand the utmost amount of care for some time. To prevent inflammatory attacks of the air-passages or lungs, the air of the apartment should be kept at a uniform temperature,—about 70°,—and to prevent the inspiration of dust the wound must be covered with a square of linen moistened with carbolic acid and water (one part of the acid and forty parts of water). All accumulations of mucus or blood in the wound are to be care-

fully wiped away, and cough and restlessness allayed by suppositories of opium or the use of morphia hypodermically.

Cases may occur in which, from inflammatory swelling or internal granulations, suffocation will be threatened. When not relieved by opening the wound, it will be necessary to perform tracheotomy and insert a tube below the point of obstruction.

Should the granulations become exuberant,—a condition which, in consequence of the disturbance of the parts, is not unfrequently met with,—they must be repressed by the use of nitrate of silver. The cicatrization which follows extensive wounds of the larynx or trachea sometimes produces such contraction or narrowing of the tube as seriously to impede the entrance of air; and if the case becomes urgent, the only alternative is to open the trachea, if possible, below, and introduce a tube. Through such an opening dilatation of the stricture has been accomplished by means of rubber bougies. Liston, Cohen, and others have reported cases of cure by this plan.

It may happen that the wound does not entirely close up, but terminates in a small aerial fistula, in consequence of which the voice is left incomplete. The operation for closure is often unsuccessful. If there be no cause, such as stricture or other obstruction, contra-indicating its cure, the circumference of the opening may be freshened, and if the edges do not readily come together the integument should be loosened from the parts beneath and united by several interrupted sutures across the opening, after which a compress placed over the parts and firmly retained by adhesive strips passing to the back of the neck will complete the dressing and prevent emphysema from the air getting between the skin and cartilage. If sufficient integument cannot be obtained in this way to close the opening without tension, it is better to adopt an antiplastic method and slide or turn in a flap from the neighboring parts. I successfully treated a laryngeal fistula some time since by this plan. The operation consists in first freshening well the circumference of the fistula and then lifting a tongue of integument in front of the larynx and trachea below, its base corresponding to the inferior semi-circumference of the fistula; this tongue is rolled upon itself, forming a cylindrical plug, pressed into the opening, and united to its border by the twisted suture. In this operation there is certainly less danger of the air getting between the skeleton of the larynx and the soft parts.

FIG. 223.

Dressing of a wound in the posterior cervical region by the sling of the nape of the neck.

The larynx may be severely contused by a blow, by the grasp of the hands in a street-fight, or by the garrote of the highwayman. After such injuries there will be soreness and swelling of the neck, pain on swallowing, and partial or complete loss of voice from injury to the laryngeal nerves; and, when the violence has been severe, loss of consciousness, and even death.

The treatment consists in surrounding the neck with hot fomentations of chamomile-tea, the warmth and moisture being retained by covering with oiled silk. Should much swelling follow the injury, with increasing difficulty of breathing, laryngotomy or tracheotomy will be demanded.

In the treatment of wounds of the back of the neck, the head must be kept somewhat extended, the edges brought together with deeply-inserted interrupted sutures supported by adhesive strips, and a compress laid over the parts, which will be best retained by a sling for the nape of the neck. (Fig. 223.)

Gunshot Wounds of the Neck.—Four thousand eight hundred and ninety-

five cases of gunshot wounds of the neck without injury to the cervical vertebræ have been tabulated from the reports of the Surgeon-General at Washington,* showing a mortality of 15 per cent. This heavy mortality is explained by the fact that the cases were taken not only from the field- and general hospitals, but also from regimental and casualty reports. These wounds were distributed as follows:

Character of Wound.	Cases.	Died.	Discharged.	Duty.	Unknown.
Gunshot wounds of the neck	4789	570	1056	2394	769
Gunshot wounds injuring trachea	41	21	11	8	1
" " " larynx	30	10	8	2	10
" " " pharynx	13	7	2	3	1
" " " œsophagus	10	6	2	2	......
" " " trachea and larynx	4	......	1	3	......
" " " trachea and pharynx	2	......	2	......	......
" " " trachea and œsophagus	2	2	......	......	......
" " " larynx and œsophagus	1	......	1	......	......
" " " pharynx and œsophagus	1	......	......	1	......
" " " pharynx and larynx	2	2	......	......	......
Summary	4895	618	1083	2413	781

The frequency with which balls traverse the neck, threading their way harmlessly through a region where so many life-structures are grouped into a space so small that one may almost span it with a single hand, is a matter of common observation with military surgeons. The only explanation which seems plausible is to be found in the form, elasticity, and mobility which belong to the cervical components. The larynx and trachea, being cylindrical, elastic, and loosely connected with surrounding parts, favor the deflection of missiles, and the movable nature of the other structures admits of their slipping out of the way of danger. On no other supposition can we explain the very striking fact that the larynx and trachea were injured only 82 times during the War of the Rebellion in 4789 neck wounds. The prominence of the larynx accounts for its being injured oftener than the trachea.

Treatment.—As in other wounds, the indications are: first, to arrest hemorrhage; second, to remove the foreign body; third, to dress the wound; and, fourth, to prevent, as far as possible, all complications.

Should the blood flow freely, it can be controlled temporarily by a finger thrust into the opening or by plugging with a roll of lint until the surgeon is prepared to adopt more radical measures. Should the blood come from one of the branches of the great vessels of the neck, the wound should be enlarged and each end of the divided artery ligated. Only will it be proper to tie the main trunk when the source of the bleeding cannot be ascertained. This course will be equally proper whether the hemorrhage is primary or secondary.

Secondary bleeding is of frequent occurrence, and when the surgeon is compelled to resort to ligature of the carotid for its control, the termination of the case becomes one of great uncertainty. This will appear in a clearer light when I state that during the War of the Rebellion the carotid was tied 29 times for injuries of the neck alone, with 22 deaths; and when we add 82 other instances in which the same vessel was ligated for various injuries of both face and neck, making a total of 131 cases, with a mortality of 97 deaths, the operation is placed in a still more unfavorable aspect. The greatest success was always obtained when the surgeon was successful in finding the branch involved and secured both of the divided extremities.

* Surgical History of the War, Part I. vol. ii. p. 414.

In the extraction of balls, portions of clothing, or other bodies, the same rules are to be observed as in gunshot wounds elsewhere. It is even more important to extract a missile from this region, when feasible, than in many other portions of the body.

Water-dressings form the best local application to such injuries.

SECONDARY COMPLICATIONS.—Aside from hemorrhage, which has been treated of, the following may be noticed.

Injury to the nerves of the neck, paralyzing the arm, tongue, glottis, and other parts, from the passage of balls, is quite common. A nerve-cord may be cut at the time of the injury, causing paralysis; or inflammatory thickening, taking place some time after, may compress a nerve-trunk so as to induce loss of motion and severe pain. The compression of a nerve may also be due to contact with a lodged ball.

During the War of the Rebellion a ward in one of the military hospitals in the city of Philadelphia was set apart for the reception of such injuries, which furnished the material for the valuable work published by Drs. Mitchell, Morehouse, and Keen.

Paralysis due to inflammatory thickening is not utterly hopeless. The absorption of the lymph may relieve the nerves from pressure, and they may again become suitable conductors of nerve-force, by which the muscular power of the part to which they are distributed will be more or less completely regained. While time has much to do with the removal of these plastic deposits, the work will be hastened by manipulation, by inunction with the ointment of the iodide of mercury, and the internal use of the iodide of potash. After there is reason to believe that the compressing cause has been removed, electro-galvanic stimulation in the course of the nerves will be productive of much good.

The fact that the mere contact of a ball with a nerve is sufficient to suspend or destroy its function suggests the necessity for making diligent search for such missiles when lodged in the neck, as their removal opens the best prospect for recovery. Two very interesting cases, one occurring in the Confederate and the other in the United States service, illustrate this point.

A sergeant belonging to the Sixtieth Alabama regiment was wounded on the 13th of March, at Petersburg, by a conoidal ball, which entered the face above the left angle of the mouth, knocking out three teeth, passing through the tongue, and lodging in the space above the hyoid bone. The bleeding, which was profuse at first, continued for several days before the vessels were secured. A careful exploration failed to discover the ball. The wound finally healed, but in the middle of the following July, after great interference in his deglutition, his tongue became paralyzed, doubtless from the ball getting into contact with the hypoglossal nerve. By the 15th of August the paralysis had disappeared. On the 20th of September severe pain set in, and an abscess formed to the right of the hyoid bone. After its evacuation he was relieved until the middle of December, when the neck became again painful, and the depressor muscles of the larynx were found to be paralyzed, indicating pressure upon the descendens noni branch of the hypoglossal nerve. An examination at this time by Dr. Michel, of Montgomery,* led to the discovery of the ball at the lower part of the neck, close to the trachea; and its extraction was followed by a complete recovery. The ball had gradually traveled the entire length of the neck, revealing its progress by the unusual nerve-symptoms which were present.

The second case was that of a private in the United States Sharpshooters, who was wounded at Chancellorsville, May 2, 1863. While in the act of firing his piece, a conoidal ball entered the left side of the neck, half an inch above and one inch from the sternal end of the clavicle, and, passing behind the trachea, lodged under the right clavicle, near where the subclavian rises out of the chest. There was very little bleeding, but a numb sensation was experienced at the elbow and in the fingers, the latter becoming flexed. From

* Surgical History of the War, Part I. vol. ii. p. 424.

carrying the limb in the flexed position, the elbow-joint finally became permanently fixed, but this false anchylosis was broken up under chloroform and the function of the articulation restored. On the 31st of October following the injury he was returned to duty, and on the 14th of September discharged from service, the limb still continuing painful and very sensitive to cold and heat. In the fall of 1865 he suddenly lost the power of supporting the head, and could not rise from bed, the head being drawn to one side by muscular spasm, which lasted only for four days. At the end of December the pain at the point of lodgment began to increase, and on the 31st of January, 1876, Professor N. S. Lincoln cut down upon and removed the ball, which was found resting against the subclavian artery, with a cord of the brachial plexus stretched over its surface. The patient recovered entirely, the limb becoming as large and as strong as the other.

Aphonia.—Partial or complete loss of voice following gunshot wounds of the neck is due to damage sustained by the larynx or trachea, to inflammatory or cicatricial changes about the vocal cords, and finally to injury of the laryngeal nerves. Many cases from these causes were reported both by United States and by Confederate surgeons. In some the disability was permanent, in others temporary. The treatment consisted in combating the inflammation, and where the life of the patient was endangered by the occurrence of apnœa, a tracheal tube was inserted.

Spasmodic cough which follows injuries of the vocal and respiratory tube may be caused by nerve-pressure. Of this nature was the case of a colonel in the Second New York Cavalry, who was wounded in Alabama on the 28th of August, 1864, by a conoidal ball, which entered the neck just above the right sterno-clavicular articulation, injured the sternal origin of the sterno-mastoid muscle and the trachea, and passed out at the upper point of the right shoulder. He was mustered out of service November 8, 1865. The muscular power of the arm was greatly enfeebled, and when a finger was pressed over the cicatrix, which corresponded to the clavicular origin of the sterno-cleido-mastoid muscles, cough and a spasmodic contraction of the laryngeal and pharyngeal muscles were excited. Loud speaking, or the pressure of a bolus of food passing through the œsophagus, would provoke similar spasms. At night he frequently experienced attacks of severe dyspnœa and constriction of the trachea. No amelioration of his symptoms had taken place after the lapse of eight years, and the inference was in favor of cicatricial pressure of the recurrent laryngeal, rather than of inflammation of its structure.*

Necrosis of the cartilages of the larynx is not an unfrequent sequel of gunshot wounds of this organ; and the hyoid bone may share a similar fate. The existence of sinuses and the use of the probe will reveal such a condition. The surgeon must wait until the work of separation has been well effected by natural processes, when the fragments may be pulled away by the forceps.

Torticollis may follow gunshot wounds of the neck from cicatricial contraction, from inflammatory adhesion of muscles, and from injury to the nerves. Several instances are given in the "Surgical History of the War of the Rebellion," where there was no reason to suppose that any nerve was damaged. This does not agree with the statement of Stromeyer, who believes that permanent wryneck does not follow gunshot wounds of the neck implicating the muscles alone.

Pyæmia, according to our army reports, was not a common sequence of neck-injuries.

Erysipelas frequently occurred after such injuries, but, independent of other complications, was rarely fatal.

* Surgical History of the War, Part I. vol. ii. p. 407.

CHAPTER IV.

INJURIES OF THE CHEST AND ABDOMEN.

Wounds of the Chest.

Chest wounds are divided into the *non-penetrating* and the *penetrating*, and may be incised, punctured, lacerated, contused, or gunshot.

Non-penetrating Wounds.—There are two varieties of the non-penetrating class, viz., the tegumentary and the musculo-tegumentary.

Tegumentary wounds possess no special peculiarities. They do not extend deeper than the fascia which covers the muscles of the thorax, and no vessels of magnitude are exposed to injury. The integument, except in front of the sternum, in consequence of the abundant cellulo-adipose tissue, is quite extensible, and therefore its wounds admit of an easy approximation, either by adhesive strips or by sutures: the latter are to be preferred, as the former are liable to become displaced by the movements of the muscles which pass from the chest to the arm. The disturbing influence arising from the great mobility of the shoulder renders it almost imperative for rapid repair that the arm should be secured to the side after the dressing of even superficial wounds in this region.

Musculo-tegumentary wounds.—The chief muscles which overlie the chest are of two kinds,—the extrinsic and the intrinsic. The former consist of the pectorals in front, the latissimus dorsi, trapezii, and rhomboidei posteriorly, and laterally the serrati and external oblique. These are broad muscles, and, with the exception of those last named, are influenced much by the movements of the arm. When a wound extends through the integument and divides a portion of one of these muscles transversely, there will be a marked retraction of its sides, save in the case of the external oblique, which, from the extended surface of its costal origin, admits of a very slight separation.

To meet these peculiarities, it will be necessary, in addition to closing the tegumentary wound with interrupted sutures, to carry the arm in such a direction as will relax and approximate the divided edges of the muscles, and to so maintain the member by a proper bandage. I have never found it necessary to adopt the practice of carrying the sutures through the divided muscles except when the wound includes the tendinous part of their structure, when it will be proper to do so, as the threads will retain their hold for some time before cutting out.

The intrinsic muscles are the intercostals, placed between the ribs, and consisting of two planes running in opposite directions.

Three planes of fasciæ also exist,—one over the external intercostals, one between the internal intercostal and the pleura costalis, and one, quite thin, between the two intercostal muscles. Wounds which extend into the intercostals, so long as they do not penetrate the innermost layer of fasciæ, are not serious, though the movements of the ribs in respiration will interfere with their rapid reparation, and the loss of intercostal resistance may possibly admit of a hernia of a portion of the lung.

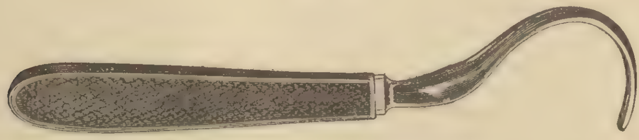
The treatment does not differ from that proper to tegumentary wounds. No stitches should be inserted into the intercostals, and the chest move-

ments, on the affected side, should be limited, either by encircling the thorax with a bandage or by broad adhesive strips carried from the spine to the sternum. If the patient suffers from cough, opiates will be demanded. Hemorrhage in non-penetrating wounds of the chest is usually slight. Along the posterior border of the scapula, and below the axilla, it will sometimes be necessary to ligate a vessel. A dangerous hemorrhage is possible from either the supra-scapular, posterior scapular, or long thoracic arteries. A fatal case is given by Dr. Dean, of the army, from a wound of the former of these vessels, the bleeding occurring on the tenth day after the injury, and another is given by Dr. Crosby, U.S.V., in which the life of the patient was in serious jeopardy from a wound of the latter trunk.* The blood, when there is not a direct opening, may collect between the muscles and form an extensive extravasation over the side of the chest. There are, however, two vulnerable points upon the chest where important vessels are greatly exposed. One is immediately below the clavicle, in a small triangular space between the deltoid and pectoral muscle, in which lie the cephalic vein and the acromial thoracic artery. The other is situated between the clavicular and sternal portions of the great pectoral muscles, at the bottom of which are situated the axillary artery, vein, and plexus of nerves. When the axillary vessels are divided in this situation, one of two results is inevitable, —sudden death, or aneurism. In the event of such an accident, should there be time for surgical interference, the subclavian should be compressed upon the first rib, in the supra-clavicular space, until the wounded vessel can be exposed below the clavicle and its divided extremities tied.

Between the two planes of intercostal muscles, near the lower border of the ribs, rest the intercostal vessels and nerve. The position of the artery is not an exposed one, and it is rarely torn, except in wounds accompanied by a comminuted fracture of the rib, in which event it is liable to be opened by a spicule of the bone. Hence wounds of the intercostal vessels are most commonly the result of shot-injuries, and are generally of a very serious import. The intercostals are quite large vessels posteriorly, and, coming directly from so large a trunk as the thoracic aorta, will, if wounded, give rise to an obstinate and profuse hemorrhage. In a case reported in the "Surgical History of the War," two quarts of blood were found in the cavity of the thorax; and of the fifteen cases recorded in the same volume, eleven proved fatal, or 73.3 per cent. Seven of these cases were treated by compression, two of which number recovered; and eight by ligature, with two recoveries. Of these eight operations, one was for primary bleeding, three for secondary, and four for intermediary hemorrhage.

When there is a comminution of the rib, the wound should be enlarged, the loose fragments of bone removed, and the vessel, if possible, exposed and tied. If this be not deemed advisable, a piece of linen cloth should be inserted into the opening, and be well packed by dossils or pellets of lint, after the method of Desault. This proving inadequate, the rib may be encircled

FIG. 224.



Author's needle for securing the intercostal artery.

with a ligature, by taking a strong, sharply-curved needle, with a blunt point (Fig. 224) having in it an eye for the thread. Introducing a strong silk thread, catgut ligature, or silver wire, through this eye, prolong the wound a little posteriorly, and, dipping the point of the needle under the lower edge

* Surgical History of the War, Part I. vol. ii. p. 519.

of the rib, follow closely its inner surface, and, by depressing the handle of the instrument, make the point present, covered by the integuments, at the upper margin of the rib. An incision should now be made so as to uncover the point of the instrument and enable the operator to remove the thread from its eye, after which the instrument should be withdrawn. The ends may be disposed of by tying them together over a roll of lint, or by passing them through the openings in a bone button and then securing the knot. Another plan of dealing with the ligature after thus encircling the rib is to pass the end which was removed from the eye of the instrument through an ordinary good-sized needle, slightly curved at its extremity, and, re-inserting it at the puncture made at the upper part of the rib, carry it between the integuments and the external surface of the rib, bringing it out at the original wound. This, which is quite easily accomplished, constitutes a subcutaneous ligation, without the inclusion of soft parts. The upper puncture should then be closed with an adhesive strip. Ligatures applied in this way unavoidably compress artery, vein, and nerve. The vessel may be compressed in another way by an instrument which I have had constructed for this purpose. (Fig. 225.) This instrument consists of two branches, the permanent

Fig. 225.

Author's intercostal artery compressor.

one (*a*) having a little mortice on its concave surface, into the middle of which is fitted a short piece of sea-tangle. The other branch of the instrument (*b*) is movable, and can be run down or up on the shank (*c*) by turning the handle (*d*). In applying this compressor, the fixed branch is passed into the wound and over the inner surface of the rib, after which the outer branch is to be screwed down upon the outside of the rib, a thin compress being interposed to prevent excoriation of the skin. The object of the little piece of sea-tangle set into the groove on the inner branch of the instrument is that by its swelling it may compress the vessel which lies below the common level of the rib in the costal groove. Professor Gross has suggested drilling a hole through the rib, and passing, in this way, a silver wire around the vessel. Whatever plan is adopted, care must be taken not to wound the pleura unnecessarily, which can only be avoided by keeping close to the inner surface of the rib.

Another source of hemorrhage is from a wound of the internal mammary artery. This vessel—a branch of the subclavian—passes through the chest between the pleura and internal intercostal muscles, resting upon the cartilages of the ribs parallel with the sternum and about half an inch from its margin. At the space between the sixth and seventh ribs its division reduces the size of the vessel so much that it becomes much less important than at a higher point. The vessel is exposed to injury from shot and other wounds which take effect near the borders of the sternum. The accident, though quite rare, was recognized five or six times during our late War of the Rebellion,* five of the cases proving fatal. The operation best adapted for tying the vessel is that of Goyrand. The first three or four intercostal spaces offer the most convenient points of access to the vessel. An incision is made two or three inches in length along the margin of the sternum, and the skin, subcutaneous tissue, and great pectoral muscle are divided, exposing the aponeurosis of the external intercostal. This last muscle is next

* Surgical History of the War, Part I. vol. ii. p. 523.

incised from one rib to the other; then, the internal intercostal being exposed, it is also divided, underneath which, unless disturbed or displaced by the injury, will be found the artery with its accompanying veins, which can now be encircled with a ligature, conducted, by means of an eyed probe, along the groove of a director passed underneath the vessel.

Penetrating Wounds of the Chest.—There are two divisions of penetrating wounds,—those simply opening the cavity of the thorax, and those implicating some portion of its contents.

The cavity of the thorax is entered whenever a vulnerating body penetrates the pleura costalis. Such wounds are made by dirks, knives, sabres, needles, bayonets, forks, balls, and other bodies.

SYMPTOMS.—When it is considered that the lungs most accurately fill up the pleural sacs, pressing against the costal arches at all points, and following the movements of the thoracic walls, it seems difficult to believe that the costal pleura can be penetrated without injury to the lungs. Of the possibility of such an occurrence, however, there can be no doubt. I have seen a number of such cases, and the experience of almost any surgeon will furnish similar examples. The entrance of air and a traumatic pleurisy are the consequences of such an accident. The first may be fraught with evil. The second does not often become more than a local inflammation, and usually proves quite manageable.

In penetrating wounds of the chest, how are we to determine with absolute certainty that the pleural cavity is opened without damage to its contents? Except, perhaps, in a very extensive wound of the intercostal structures, by which the cavity of the chest is exposed to the eye, all surgeons agree that such a diagnosis is one of great difficulty, simply because it is well known that those signs which ordinarily indicate a wound of the lung may be present without the existence of such injury.

TREATMENT.—The wound should be examined by the fingers or probe, and the surface of the chest critically inspected, with a view to ascertain the direction and location of the ball, if the missile be of that nature, always remembering the tendency of a bullet to be deflected. Sometimes the ball will be found under the skin, at other times impacted between the ribs, surrounded with a portion of the clothing of the patient, or often lodged under the scapula. Wherever found, it must be extracted, and the opening covered with a wet compress. When the wound is an incised one, it should be closed by sutures and adhesive strips, compress, and a broad bandage carried around the chest and secured sufficiently tight to control its movements. The quiet of the chest-walls is a very important element in the treatment, in view of the tendency to the formation of sinuses after such wounds. The diet should be restricted for ten or twelve days, and opium administered to allay any cough which may be present. The existence of pain in the location of the wound, aggravated on taking a deep inspiration, and accompanied by an increase in the temperature of the body and with accelerated pulse, denotes the development of pleuritis, which may extend to the lungs, giving rise to a pleuropneumonia. If the symptoms are urgent, it will be proper to abstract blood; if not, wet cups over the side of the chest will answer. These should be followed by a large warm flaxseed-meal or mush poultice, covered in with oiled silk or rubber cloth, and renewed every six or eight hours. To allay irritation, relieve pain, and maintain an active condition of the glands of the skin, four or five grains of Dover's powder, given once every four or five hours, will act beneficially.

Wounds of the contents of the chest include those which affect the organs in the pulmonary chambers, namely, the lungs, and those in the mediastina, the pericardium, heart, and great blood-vessels.

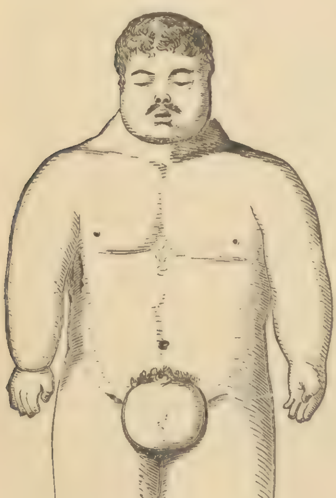
Symptoms of a wound of the lungs.—The lungs may sustain extensive damage by a contusion or concussion of the thoracic walls, producing laceration of

the pulmonary tissue, without the presence of an external wound. The same result may follow a broken and displaced rib. More commonly, lung wounds originate from knives, sabres, bayonets, and balls. By whatever cause a wound of the lung is produced, there is an immediate consciousness on the part of the patient of having received a very serious injury. It is followed by alarm, trembling, pallor, and sometimes collapse. Among the immediate effects will be the escape of blood and air. This blood may enter the air-passages and be spit up by the mouth (hæmoptysis), or it may flow into the cavity of the chest (hæmothorax), and also into the lung-tissue by infiltration. The nearer the wound is to the root of the lung, where the vessels are large, the more profuse will be the hemorrhage and the greater the danger. Should the opening in the wall of the chest be direct and sufficiently patulous, blood may flow externally; and from the same condition of the wall, a collapse of the lung will be probable, produced by the air from without and that from the damaged organ rushing into the pulmonary chamber during inspiration. A patient thus suddenly deprived of one-half of the surface of aeration will be in imminent danger of death.

The signs denotive of the accident are a struggle for breath, grasping anxiously at any object within reach, and wildly tossing from one position to another. The power of the heart is diminished, the pulse becoming very feeble; the surface is cold, clammy, and bloodless; and there is inability to lie for any time on the sound side. The physical signs are, the absence of the usual respiratory sounds, preternatural resonance, and immobility of the walls of the chest, on the affected side, while on the sound side both the movements and the pulmonary sounds are greatly exaggerated, in consequence of the extraordinary demands made upon the uninjured lung.

Escape of air.—This is another evidence of perforation of the lung. When the air escapes into the cavity of the pleural sac, it constitutes pneumothorax. A stratum of the atmosphere surrounding the lung, while it increases the difficulty of respiration from the resistance which it offers to the inspiratory expansion, does not necessarily involve collapse: indeed, both sides of the chest may be opened without collapse of the lungs, though the occurrence of such a condition must be exceedingly rare. Should the opening be sufficiently large, the air may be heard passing in and out of the chest during expiration and inspiration.

Fig. 226.



Emphysema of the entire surface of the body.

Fromotopnœa.—Air expelled from the wound, and intermixed with blood and mucus, presenting a frothy or foam-like appearance, is a very significant sign of a wounded lung; and the same is true if a bloody and frothy mucus is expectorated. The air may escape into the interlobular tissue or beneath the pleura pulmonalis, constituting pulmonary emphysema; or, instead of passing out of the wound, it may be disseminated through the cellular tissue of the side, giving rise to external thoracic emphysema, indicated by the crackling sound experienced when pressure with the fingers is made upon the integument. This emphysema may extend over the entire side, or even over the whole body. (Fig. 226.) The facility with which air may be diffused through the open spaces in the subcutaneous connective tissue is sometimes taken advantage of by professional beggars, who, in order to excite popular commiseration, make a puncture through the skin of a child, and, inserting the fine nozzle of a syringe, inflate the integument.

It must be observed, however, that all of the enumerated signs may be present without a wound of the lung,—a fact which renders the diagnosis one of considerable uncertainty.

Hæmoptysis may follow a concussion of the chest and also a non-penetrating wound of the same; and it is possible to mistake the source of such hemorrhage. I recall a case in which it was supposed to have come from a lesion of the lungs, when on a closer scrutiny it was found to proceed from a large syphilitic ulcer in the fauces. If, however, the blood be intermingled with a frothy mucus, the evidence is in favor of a lung-penetration.

Emphysema and pneumothorax are also possible without any implication of the lung. The air may be drawn into the chest through the external opening during inspiration, and, in consequence of the non-correspondence of the opening in the integument with that through the intercostal space, it is not expelled in the act of expiration, but becomes diffused through the cellular tissue exterior to the walls of the thorax, giving rise to *emphysema*. That this is not a common sequence of penetrating wounds will appear from the statement made in the Surgical History of our late war,* that in 8715 cases it was observed only thirty-eight times. Air may also collect in the pleural cavity, forming pneumothorax. The final disposal of the air in emphysema or pneumothorax has been the subject of much conjecture. There can be little doubt that, mixed with the fluids with which it is surrounded, it becomes absorbed. It is difficult to imagine any other solution of the problem, when we see an enormous tympany of the intestines disappear in a few hours without expulsion through either outlet of the alimentary canal.

Pain and cough.—The pain is usually burning in character, and the cough a suppressed and worrying one.

There are other diagnostic signs, which are equally equivocal with those already named, such as the size of the wound and its comparison with the dimensions of the vulnerating blade, and the relative position and posture of the assaulter and assaulted. While it is quite proper to take these into the consideration of obscure cases, they must not be invested with too much importance. A wound equal to or much greater than the widest part of a knife-blade is often inflicted with a trifling depth of penetration. A sabre or sword wound may pass several inches between the soft parts and the ribs without opening the cavity of the chest; and balls often follow a circuitous route, both without and within the chest, without implicating the lungs.

The surgeon may be induced to try certain tests, which I mention only to condemn, as being not only hazardous, but also unreliable. The first is to instruct the patient to endeavor to force air through the external wound by taking in a full inspiration, and then, holding the breath in order to close the rima glottidis, to make an attempt at expiration, while a taper is held at the orifice of the wound (the sides of which are separated), under the supposition that if the lung be wounded the air will be driven out and disturb the flame. The possibility that the expelled air has entered through the wound, or that a clot or a transudation of lymph with inflammatory swelling may prevent the escape of air, even when a lung is wounded, is a sufficiently cogent reason for objection; but there is another of much more weight, *i.e.*, that the experiment is not unattended with danger, as it may dislodge a clot, break up adhesions of the lungs, and otherwise disturb the work of repair, upon which the life of the patient may be suspended.

The same objections apply with equal if not greater force to that meddlesome surgery which dares to introduce a probe or a finger through the opening in the walls of the chest. The following case will serve as an instance of the evil effects of such interference. A private, belonging to the 111th New York Volunteers, was wounded, April 2, 1865, at Petersburg, by a conoidal ball, which entered the left side, near the spine, between the eighth and ninth ribs, and lodged in the thorax. He was sent to a field-hospital at City Point. He had hemorrhage and hæmoptysis, and was greatly depressed. He rallied,

* Surgical History of the Rebellion, Part I. vol. ii. p. 613.

however, from the shock, and was sent to the Armory Hospital, Washington, on April 5, where he died April 6, from the displacement of a clot during an examination of the wound.*

Lumbar ecchymosis has been noticed in chest wounds, but is so rare that its value as a diagnostic sign will be seldom appreciated.

Seeing, then, that there are no signs which declare with absolute certainty the existence of a lung wound, and, moreover, since it is not essential to the management of a case that such knowledge should be attained, the surgeon will wisely refrain from pressing his inquiries into the region of danger.

Complications.—These are immediate and remote, or primary and secondary.

The immediate or primary complications result from the presence of a foreign body in the cavity of the chest or in the lung, such as a ball, shot, wadding, or portions of the clothing; air in the pleural sac,—pneumothorax; air in the cellular tissue on the outside of the chest and in the interlobular tissue of the lung,—emphysema; blood in the pleural sac,—hæmothorax; blood in the tissue of the lung,—traumatic pulmonary apoplexy; and, lastly, hernia of the lung.

The remote or secondary complications are the result of inflammatory changes, and are—an accumulation of serum or pus in the cavity of the pleura, constituting hydrothorax and pyothorax; pleuritis, gluing the pulmonary, costal, and diaphragmatic pleuræ together; pneumonia, fistula, and hernia of the lung or pneumocele. The last is occasionally a primary complication, as has already been stated.

Prognosis.—The gravity of wounds involving those portions of the chest which accommodate the organs of respiration must be determined by their depth. When the wound does not penetrate the thoracic parietes, a favorable termination may be expected. Even in gunshot flesh wounds, where there is often the additional element of visceral concussion, the mortality is very low. Macleod records, during the Crimean War, 255 wounds of the soft parts of the chest, with but 3 deaths.

The reports from the Surgeon-General's Office at Washington furnish 11,549 cases of flesh wounds of the chest during the War of the Rebellion. The result was ascertained in all but 658. Of the remaining number—10,891—only 113 died, about 1 per cent.

When the chest has been subjected to severe contusion or concussion, such as is caused by railroad accidents, by the falling of walls or the timbers of houses, by spent cannon-balls, or by fragments of shells, the prognosis should be given with great reserve, as extensive damage is frequently inflicted upon the internal organs without any very marked injury being visible upon the surface.

In penetrating and perforating wounds the danger to life is very great. The testimony of all military surgeons concurs on this point. Balls, pieces of clothing, and other materials, may remain quiescent for some time in the cavity of the chest; or they may find their way by ulceration into a bronchial tube and be coughed up, or into the œsophagus or even the intestine, and find their way safely out of the body, the patient making a good recovery; but these are the exceptional cases. Oftener the patient is worn out by protracted suppuration and the consequent irritative fever. By some, these injuries of the contents of the chest are supposed to develop phthisis pulmonalis. Hennen† mentions one case of this kind. Other writers‡ have furnished instances in which it is asserted that tuberculosis of the lungs was cured by wounds of the pulmonary organs. The evidence offered in either case, however, will not bear even a lenient criticism.

In the War of the Rebellion the result was ascertained in 8404 cases of this class of chest wounds, furnishing a death-rate of 62.5; and when this is placed in comparison with the reports of others, the result is found to vary

* Surgical History of the War, Part I. vol. ii. p. 482.
† Hennen's Principles of Military Surgery, p. 391.
‡ Larrey's Mémoires, tom. iii. p. 376.

but little. This is well exhibited in the following table of chest wounds, collated by Dr. Otis* from different writers.

Action.	Wounds.	Died.	Mortality-rate.
New Zealand (Mouat)	23	15	60.8
French in the Crimea (Chenu)	491	450	91.6
British in the Crimea (Matthew)	164	130	79.2
French in Italy (Chenu)	256	119	46.48
Austrians and Italians (Demme)	159	97	61
Hanoverians in Schleswig-Holstein (Stromeyer)	97	17	17.6
Prussians in Danish War, 1864 (Lœffler)	137	57	41.6
Danes in Danish War, 1864 (Lœffler)	113	76	67.2
Prussians in Six Weeks' War (Maas)	12	4	33.3
Prussians at Langensalza (Stromeyer)	47	31	65.9
Prussians at Landeshut (Brefel)	15	8	53.3
Germans in Franco-Prussian War (Billroth)	30	9	30
Germans near Metz (Fischer)	34	19	55.8
French at Sedan (MacCormac)	31	17	54.8
Total	1609	1049	65.2

When the ribs are broken by the penetrating missile, extensive laceration of the lungs may follow. It has been observed by Dr. Brinton that fractures at the point of entrance are much more serious than those at the point of exit,—that is, when a ball on entering the chest strikes a rib, carrying before it fragments and spiculæ of the broken bone, the injury is usually fatal, whereas when it enters through an intercostal space, and breaks the rib in passing out, the danger is materially lessened. This may be asserted of all penetrating wounds of the chest. The danger is enhanced by the addition of a fracture of the clavicle and of the scapula. The laceration produced by balls, fragments of shells, and portions of clothing renders such wounds more fatal than those made by incision or puncture, on account of the sloughing and suppuration which follow the former. The less the penetration and the more remote from the root of the lungs, the greater is the prospect of recovery, in consequence of the diminished risk of profuse hemorrhage.

When the foreign body remains in the chest, the prognosis becomes less favorable, though should it become encysted the danger may be delayed to a distant day. Judging from my own observation, and from cases of reported recoveries in which the certainty of the lesion was often obscure, I cannot resist the conclusion that the mortality is much greater in wounds of the lungs than writers generally represent. The chances of recovery are greatly enhanced if the patient survives five or six days without sloughing symptoms.

I am not aware that there are any cases of permanent recovery after a gunshot wound of both lungs.

Treatment.—The treatment in penetrating wounds of the chest is local and constitutional.

The local treatment includes a careful inspection of the wound and the removal of any foreign body which can be discovered. How far such examination is to be carried must be determined by the judgment of the surgeon. If there has been much hemorrhage before the patient is seen, and clots are discovered in the opening, it will be wise not to disturb them for the present, as their displacement will probably provoke a renewal of the bleeding; but where such a condition does not exist, it is allowable to use both the finger and the probe to determine if any foreign matters are accessible. Beyond establishing this point, further explorations are pernicious. When the opening is made by a ball, a water-dressing should be applied, and confined either by a

* Op. cit., p. 608.

T-bandage of the chest or by adhesive strips; if the opening is a punctured or an incised one, it should be closed with sutures and adhesive plasters.

When blood and air escape very freely, the question arises, Is it proper to seal up the wound, or not? This is best determined by the circumstances of the case. I have had occasion to adopt both plans with success. To attempt what is called "hermetically sealing" every case of penetrating and perforating wounds is simply unphilosophical. The absurdity of such a practice has been very thoroughly shown by the masterly analysis of Dr. Otis, of the United States Army.

When a moderate amount of blood and air escapes through a chest wound, the opening should be drawn together by sutures and adhesive plasters. If the flow is profuse, the wound should be allowed to remain open, as otherwise there will follow hæmothorax and pneumothorax, with attendant distress in the breathing. If, under any circumstance, severe dyspnœa should follow the closure of the wound, it should be opened. In order to favor the evacuation of the blood, the patient should be laid on the affected side, so as to make the wound dependent. Much comfort will be realized by giving to the chest a proper support, leaving the opening uncovered, either by the many-tailed bandage or by adhesive plasters passing from the spine to the sternum, as is done in the dressing of a broken rib. The latter mode is to be preferred, as the plasters, being confined to the affected side, leave the other unembarrassed for the work of respiration. When the ribs are comminuted, loose fragments are to be cautiously picked away, in order that no additional injury may be done to the pleura or the lung.

The constitutional treatment consists in confining the patient rigidly to the recumbent position. He should not be allowed to rise either to urinate or to defecate. Cough will be best relieved by Dover's powder. The bowels must be regulated with laxatives, when necessary; and the diet must consist of nutritious but unstimulating food, such as iced milk, and chicken or beef broth. The depressed or collapsed state which so frequently attends wounds of the lung, unless extreme, is of vastly more importance to the patient than all the remedial resources of the surgeon, as it conduces to a natural hæmostasis. When reaction sets in, it must be watched with the utmost vigilance. The small clots which have obstructed the divided vessels must, if possible, not be dislodged; and whenever the heart begins to beat with a force which impels the blood too forcibly against these little blockades, it must be weakened by a depressant, the best being either veratria or aconite.

Immediate Complications. *Hemorrhage.*—This is among the most common as well as the gravest of the complications of penetrating chest wounds. It occurred in 346 out of 8715 cases during the War of the Rebellion, 137 proving fatal.* When the hemorrhage is profuse, and comes from the wound or the mouth, or from both, the chest should be surrounded with ice-bags, and full doses of fluid extract of ergot administered every half-hour. The wound must be allowed to remain open, and the patient be placed in a position to admit of the free escape of the blood,—that is, on the wounded side. If the hæmoptysis does not diminish, and the strength of the patient begins to fail, the wound must be closed, the external refrigerant applications continued, and heat applied to the extremities. Should the pulse, color, and temperature improve, there is encouragement to persevere in this course; but if the pallor and dyspnœa increase, and the pulse becomes more feeble, it is apparent that the blood is flowing into the chest and compressing the lung, consequently the wound should be immediately opened, and the patient turned on the injured side, to favor the escape of the blood. But suppose, notwithstanding this be done, that the hemorrhage continues with unabated violence: shall the wound be again closed, in the hope of stopping the flow by imparting pressure to the bleeding lung and thereby favoring coagulation, even at the risk of being compelled to open it again? Such undoubtedly would be the proper course to adopt. In addition to this measure, the

* Surgical History of the War, Part I. vol. ii. p. 612.

surgeon should, besides keeping the external application of cold to the chest, administer one-drachm doses of the wine of ergot, with a few drops of laudanum, every twenty-five minutes, until eight or ten doses have been taken, when the remedy should be discontinued, or exhibited at longer intervals. In emergencies like the above, it was the practice among military surgeons, even as late as the Crimean War, to open a vein in the arm, and by free venesection induce, as rapidly as possible, a state approaching to syncope, in order to control the bleeding. This practice, employed without discrimination, doubtless has destroyed many lives, and that it is both unnecessary and dangerous has been well shown by the experience of Dr. Frazer,—the first to expose this error,—as well as by that of our own surgeons during the recent War of the Rebellion. In a case, however, where the hæmoptysis is so profuse as to threaten to destroy the life of the patient in a very short time, or where there is reason to believe that blood is infiltrating the lung-tissue, I concur in the propriety of venesection, as I have seen the most convincing proofs of its efficacy; but, except in such a desperate strait, where the object is to gain a little time for the action of remedies, bleeding from the arm should be discouraged. Antimony has been recommended, in virtue of its depressing influence upon the heart; but the prostration which sometimes follows its use renders it a dangerous agent and one entirely unsuited to such cases. The fact that we have in veratrum viride and ergot remedies capable of lessening the power of the heart and of contracting the calibre of vessels without producing sickness, and that these remedies can be managed with so much certainty, renders both the lancet and antimony unnecessary, except in the extreme cases mentioned. If, by the means already enumerated, the hemorrhage is brought under control, and the patient survives five or six days, there is ground to hope that recovery will follow, though the bleeding be renewed, as it sometimes is, even after the lapse of three or four weeks. The word recovery should be used in a guarded sense. It may be complete and permanent as applied to the immediate symptoms, though often the injury lays the foundation for subsequent disease, which will terminate fatally.

Hæmothorax.—When the blood, instead of escaping, accumulates in the cavity of the thorax, it constitutes what is called hæmothorax. If the quantity of the fluid is great, the lung will be compressed, preventing its expansion, and giving rise to dyspnœa. This condition may be suspected when the pulse becomes feeble, the skin cool and moist, and the countenance pale, and when nausea, restlessness, and diminished respiratory chest movement are present. The physical are more decisive than the rational signs. There will be dullness on percussion, most marked at the dependent portion of the chest, with a corresponding absence of the respiratory murmur. Should the pleural sac become filled with blood, the percussions will be dull or flat over the entire side, the intercostal spaces will be bulged out, and all sounds, whether respiratory or vocal, will be entirely destroyed. Lumbar ecchymosis will sometimes exist, though there is such a want of uniformity in this particular sign that its absence will have little weight in our diagnosis. The lumbar discoloration is produced by a slow leakage of blood between the muscular fasciculi of the diaphragm and those of the quadratus lumborum, the liquid extending around to the inner margin of the erector spinæ muscles and diffusing itself through the cellular tissue over the loins. For the existence of such an extravasation it is necessary that the blood should find its way beneath the reflected pleura, and this can take place only through the opening made by the vulnerating body; whence its infrequency.

The prognosis must be formed by the extent and persistence of the bleeding. When the quantity of blood is not great, as indicated by the percussion and auscultatory sounds; when the pulse increases in force and diminishes in frequency, the color returning to the face and lips; when the patient becomes composed, and the breathing less embarrassed, a reasonable hope of recovery may be entertained.

TREATMENT.—The treatment consists in closing the wound, as already described, in the hope that the flow may be arrested by the pressure of a coagulum. Should the difficulty of breathing, and the other signs of hemorrhage, increase, the wound must be opened, and the patient be placed, as far as possible, in such a position as will make the opening dependent, in order to favor the escape of the blood. Should the fluid have become clotted, it may be found impossible to dislodge it through the original opening, and other measures should be adopted to accomplish the desired object. In some instances the opening has been enlarged. If there is sufficient reason to believe that by increasing this outlet the blood will escape, then let it be done; and this conclusion may be reached if the clots are found pressing into the wound and there becoming fastened. When such an operation is not deemed proper, it will be better to close up the wound, and to aspirate the chest through a lower intercostal space with a large-sized trocar, so that the coagula may pass through.

Emphysema.—The extravasation of air through the cellular tissue exterior to the cavity of the chest, which may be known by the crackling sound elicited upon pressure by the fingers, is not a serious complication. It is a very common sequence of a broken rib, where the lung has been scratched; and I have never found that it seriously complicated the favorable progress of the case, though Mr. Erichsen states that in a case of this kind he has seen suppuration follow, bathing the broken ribs in pus. When there exists an external wound, and the air reaches the subcutaneous tissue, during either inspiration or expiration, so long as it remains within reasonable bounds it may very properly be left to nature, the closure of the wound and a proper degree of compression generally effecting its removal. If it becomes of sufficient importance to demand interference, the surgeon should examine the direction of the wound. If the external and internal openings do not correspond,—that is, if the communication between the two is indirect or circuitous (a peculiarity often causing the emphysema),—let the communication be made direct by an incision; or if the difficulty is not explainable in this way, a few punctures may be made, followed by compression with a bandage to an extent consistent with the comfort of the patient. Pulmonary emphysema is an occasional result of a lung wound, the air passing between the lobules or beneath the pleura of the lungs. It will be noticed under the next head.

Pneumothorax.—Like emphysema, with which it is generally associated, pneumothorax may arise from the air entering the chest through an external opening, or from the air-cells of the injured lung. When it accumulates to a degree sufficient to compress seriously the lung towards its root, it will give rise to much distress, offering the same resistance to the entrance of air into the lung as is presented when the latter is compressed by blood.

The symptoms which indicate pneumothorax are, dyspnœa, pain, extraordinary resonance of the chest, the absence of the usual respiratory and vocal sounds upon the affected side, and an exaggeration of these sounds on the uninjured side, in consequence of the increased labor devolving upon the normal lung. When the injured side is only partially filled with air, the obstruction to the function of the lung being less, both the rational and the physical signs will be modified. The percussion sound will be less tympanitic, and the vocal and respiratory murmurs possess a pitch which is expressed by the term "metallic tinkling." The difficulty of breathing will also be less urgent. The chief distinguishing characteristics between lung-pressure from blood and that from air are, that in the latter there is resonance of the chest-walls and the ordinary signs of internal hemorrhage are absent.

When the air-cells become dilated, or when the air infiltrates the interlobular tissue of the lungs or the space beneath the pulmonary pleura, it will give rise to symptoms analogous to those of pneumothorax, but susceptible of being distinguished from them. In these forms of emphysema the percus-

sion sounds are somewhat less resonant than in pneumothorax, the expiration more prolonged and difficult, and the respiration more feeble and asthmatic, with absence of metallic tinkling.

Treatment.—So long as the air in the pleural sac does not seriously impede the breathing, interference is unnecessary, as this air will eventually be absorbed. When, however, the respiration becomes labored and the patient is threatened with suffocation, an attempt must be made to effect its escape. Here, as in hemorrhage, the wound should be opened, and, if not sufficient, may be enlarged. If the opening has healed, or does not afford vent for the air, the chest should be tapped with the aspirating apparatus.

Hernia of the lung, or pneumocele.—A portion of the lung may insinuate itself between the lips of a chest wound and protrude externally, constituting what is called a hernia of the lung. This may follow immediately after the accident, or it may be formed weeks later, in which last case it overcomes the resistance of an insufficient cicatrix. This complication was noticed seven times in twenty thousand cases of chest wounds reported during the War of the Rebellion, five of which seven were primary. Though it is said that these protrusions occur most frequently at the anterior part of the chest and on a line with the nipple, yet in the cases alluded to above, five were as low as the ninth rib. All were the result of gunshot wounds, and varied in size from one to five inches in diameter. Several reasons have been offered in explanation of these protrusions of the lung. I am disposed to believe that the cause is to be referred to peculiarities of structure. Every anatomist will have observed among a large number of cases certain ones in which the fissures separating the lobes of the lungs are very deep, by which great freedom of movement is allowed, thus favoring a protrusion when the resistance of a portion of the walls is removed.

Diagnosis.—In primary pneumocele the diagnosis is not difficult. The extended mass is of a deep-chocolate color and crepitates under pressure. When it is secondary it will be covered by the integuments and some connective or cicatricial tissue. It will exhibit a noticeable change of form, swelling during inspiration and subsiding on expiration. When pressed under the fingers, crepitation will be felt. Percussion will elicit a clear sound, and auscultation will detect the soft vesicular murmur.

Prognosis.—Of the cases reported to the Surgeon-General of the United States Army, three, it is believed, proved fatal; but, as there were additional complications involving the abdominal viscera, death cannot be fairly attributed to the pneumocele. There is reason to believe that, aside from other injury, the accident is one from which recovery may be looked for.

Treatment.—As there is but a single case on record where a successful reduction of a pneumocele has been effected,* all efforts with that end in view will most likely prove fruitless, and for this reason persistent attempts to restore the lung should not be made. When projecting through a wound it is likely to become strangulated by the entrance of blood and air, in which case it becomes dark-colored and sloughs off. Two plans are open to the surgeon: either to leave the mass alone, only protecting it by a piece of lint wet with carbolic acid and oil until nature casts off the slough, or to encircle the neck of the tumor with a ligature on a level with the surface of the chest, and strangulate it at once. When the mass is dead, it should be sliced off externally to the cord with a scalpel, and the stump treated with carbolic acid and oil. In secondary cases of pneumocele—generally the most common—the only thing to be done is to protect the swelling against injury by wearing a shield which can be attached to a T-bandage surrounding the chest or to a spring similar to that used in the ordinary truss.

The primary or immediate complications of chest wounds, such as the presence of missiles, blood, or air, together with the traumatic violence, tend

* Gazetta Medica di Milano, Feb. 1844; Surgical History of the War, Part I. vol. ii. p. 568.

to excite secondary complications of an inflammatory nature. These are as follows:

Pleurisy and pneumonia.—It has not been my privilege to examine many fatal penetrating and perforating wounds of the chest; but, so far as my experience extends, in cases where the patient has lived sufficiently long, inflammation either of the pleura or of the lungs, or of both, has been invariably present, though, as a rule, quite circumscribed in extent. It is doubtless true that this form of pleurisy and pneumonia is, save in exceptional cases, generally limited to the neighborhood of the wound, and does not greatly exceed the extent which is necessary for the repair of the injury. If this be so, neither pleurisy nor pneumonia can be justly regarded as a complication.

Symptoms of traumatic pleurisy do not differ materially from those of the idiopathic disease. There is pain on inspiration, though not, as a rule, so acute as in the latter, and this pain may exist in so slight a degree as to excite no complaint. The friction-sound in traumatic pleurisy is generally circumscribed.

The signs which are said to indicate traumatic inflammation of the lung are of doubtful value. The escape of air into the chest, the imperfect dilatation of the pulmonary organ, and sometimes its complete collapse, render the percussion and auscultatory sounds exceedingly unreliable. In a case which I saw with a physician in the southern part of this city, in which a man in a fit of jealousy plunged a knife into the side of a young woman, and where there could scarcely be a doubt that the lung was wounded, which injury I have reason to believe was followed by a limited pneumonia, the physical signs were valueless. Instead of flatness on percussion in these cases we may expect resonance from the pneumothorax present, while the non-expansion of the lung will prevent our recognizing either crepitant, subcrepitant, or bronchial sounds. The same uncertainty will attach to all inferences drawn from the rational signs. The difficulty of respiration, cough, pain, discolored sputum, and accelerated circulation may exist entirely independent of pneumonia. An intermixture of blood with purulent matter in the expectoration, coming on from three to four days after the accident, will furnish a reasonable ground for supposing the presence of the disease.

Treatment.—The treatment in cases of traumatic pleurisy and pneumonia should be chiefly expectant. Too much importance cannot be attached to the matter of rest. The chest should receive a support of broad adhesive strips, carried from the spine to the sternum. Opium, in the form of Dover's powder, to allay cough, pain, or nervous restlessness, and to secure more perfectly the enjoined quiet or rest, will prove invaluable; and should the pulse become too frequent and full, veratria will be the best remedy to secure its reduction. The diet most desirable for the first four or five days will be milk and light broths, after which solid food may be allowed. Neither bleeding, calomel, nor antimony is indicated, for if the inflammatory disease is local in its character it is probably not greater than the necessities of the case demand. A transudation of lymph and leucocytes is required to unite the damaged parts, and whatever tends to interfere with such a work must cause evil instead of good. Of all the inflammatory affections following wounds of the chest, which I have treated in civil and military hospitals and in private practice, in none have I taken blood from the arm; and when I had reason to believe that the disease was transcending the limits of safety, dry cupping, followed by a blister, was found to answer every purpose. And I may say that so uniform have been the recoveries that there remains but one of two conclusions: either there was an error in diagnosis or the treatment was peculiarly suited to the injury.

Hydrothorax and *empyema*—the first an accumulation of serum and the second of pus in the pleural sac—are frequently met with as secondary complications of chest wounds, and also as primary and secondary results of inflammation of the pleuræ. From whatever cause, we are not to expect to

find these fluids typical examples of serum and pus. The former is often stained with blood, especially when of traumatic origin. When hydrothorax follows acute pleurisy, the fluid may be almost colorless or of a straw color, its consistence thin and watery, or thick like syrup, and containing flakes of lymph. The pus in empyema does not answer to what we ordinarily see discharged from an abscess in a healthy person. It is puriform rather than purulent, thin rather than consistent, contains curd-like masses of unhealthy lymph, is often discolored with blood, and may be charged with foul gases, emitting, when drawn, an offensive odor. It is astonishing with what rapidity such accumulations will form. I once saw a young man who, immediately on being attacked with a severe pain in the side, left Princeton and came direct to Philadelphia,—a two hours' ride. On the evening of the same day, when I visited him, the right chest was filled with fluid.

Accumulations of this nature may occur so quietly and gradually, and cause so little uneasiness, as scarcely to be suspected. In chronic inflammations of the pleuræ we have examples of this kind, and especially where they have a tubercular origin. These are the cases which furnish illustrations of enormous thickening of the pleura, with its surface encrusted with a thick deposition of sedimentary matter, or of transformations here and there into a dense fibro-cartilaginous or bone-like substance. Pus may accumulate in the cavity of the chest by the rupture of a vomica, the opening of a pulmonary abscess, and, in rare cases, of an hepatic abscess. The purulent matter is occasionally found encysted by a circumscribed adhesion of the costal and pulmonary pleuræ, and Dr. Townsend records the case of a patient who died in the Whitworth Hospital, in which the pleural sac was divided into three chambers, each containing pus.* Recently I tapped a child four months old, in whom a post-mortem revealed this separation of the pleura into distinct compartments. This is a matter of much practical importance in the operation of paracentesis thoracis, as each sac will probably require a distinct puncture of the trocar.

Symptoms.—The rational signs of hydrothorax or empyema are short and difficult breathing, often performed with a peculiar grunting sound, a constant sense of oppression, and, when the accumulation is great, a general enlargement of the side, with bulging of the intercostal spaces and sometimes œdema of the overlying integument. The patient, in most cases, will find the easiest position to be that on the affected side. The history of the patient must be taken into account, such as the existence of a previous injury, pain in the side, rigors, frequent pulse, flashes of heat, etc.

The physical signs are the following: a dull or flat sound on percussion, corresponding to the height of the accumulation, and therefore most marked at the base of the chest when the patient is placed in the sitting posture. If the thorax be shaken, a splash may be heard and felt, provided the fluid be sufficiently liquid, similar to that which one hears when a partially-filled vessel is agitated. The vocal resonance will be diminished, and, if the collection is of sufficient magnitude and on the left side, there may follow displacement of the heart or the lung may be compressed against the posterior part of the chest so as to force out its air. Such a condition will prevent pulmonary expansion, and will obliterate all voice or breathing sounds.

In order to make the diagnosis perfect it is always safer to use the exploring-needle, the introduction of which will communicate the desired information. It is possible to confound an abscess in the parietes of the thorax with a deposit of pus in the pleural cavity pressing its way through an intercostal space. The differential diagnosis may be established by remembering that, if the external swelling communicates with the cavity of the chest, its size or prominence will be influenced by full inspirations and expirations, being diminished in the former and increased in the latter; if in the parietes, the swelling will not be affected by these movements.

Treatment.—When the accumulation of serum or pus is small, the health

* Cooper's Surgical Dictionary, vol. i. p. 622.

of the patient not too much broken down, and the disease not due to tuberculous disease or to the presence of foreign bodies in the lung, much may be done by proper local and constitutional remedies in effecting the removal of the fluid. Where there is reason to believe, in consequence of local pain and an elevated temperature, that a chronic inflammatory condition of the pleuræ still exists, a large blister over the chest will be indicated; or, where such condition does not exist, the thorough application of the compound solution of iodine will prove of value. Should the accumulation have an acute origin, we may administer active cathartics, such as bitartrate of potash, or diuretics, the best of this class being the infusion of digitalis.

In the majority of these cases under consideration we have to deal with a low grade of inflammation, and in constitutions much enfeebled by previous disease or injury we are compelled to rely upon tonics and alteratives, with nourishing food and fresh air. The syrup of the iodide of iron and cod-liver oil, and the iodide of potash with the tincture of cinchona, are remedies which will also be found to prove exceedingly useful. Jaborandi possesses active diuretic properties, and has been used with success in thoracic accumulations of a sero-purulent nature. When, however, the collection is large, so much so as to embarrass the respiration and injuriously compress the lungs, the only alternative is the evacuation of the fluid through an artificial opening in the walls of the chest.

During our late war paracentesis thoracis was performed 28 times, with 9 recoveries; in all of these cases, save 8, the necessity for the operation arose from traumatic injury. Of the 25 cases reported by Dr. Hughes,* in which this operation was done in Guy's Hospital, London, 13 recovered. Of 10 cases of empyema treated by operation under the care of Dr. Peter, at La Pitié,† 7 were entirely successful. The French—and among them Trousseau especially, who was one of the first to perform this operation—are more given to tapping the chest than either the English or the American surgeons. Among Americans, Drs. Wyman and Bowditch have done much to popularize the practice. Of 79 cases tapped by the latter gentleman, 29 recovered. More recently I learn that Dr. Bowditch has operated 200 times upon 154 patients; but the results I have not been able to ascertain.

There is reason to believe that we are generally too backward in puncturing the chest for the relief of these collections. A large accumulation of pus cannot lie harmlessly in the pleural cavity for any length of time. It is damaging to the lung, and must in some degree vitiate the blood and induce hectic symptoms.

The operation of thoracentesis.—In the performance of this operation the indications are to open the chest at the lowest point consistent with safety, and to avoid wounding either the lung, the diaphragm, or the intercostal vessels. On the right side the sixth, and on the left the seventh, intercostal space will be the proper ones to puncture. The presence of the liver makes it safer to select a higher point on the right than on the left side. In persons who are very fat, rendering it difficult to distinguish the ribs, the proper intercostal space on the right may be ascertained by remembering that the seventh rib—the lower boundary of that space—is the last one attached directly to the sternum: by placing the finger upon this point, and tracing the rib towards the spine, we are enabled to recognize the place for operation. For the left side a similar procedure will answer equally well, as the lower border of the seventh rib forms the upper boundary of the proper or seventh intercostal space. In these directions it must be understood that the intercostal spaces are enumerated from above downwards. Having ascertained the proper space, the next important step is to determine the point for puncture, which should be about midway between the spine and the sternum and immediately above the upper margin of the rib, that the vessels which lie within the lower border shall not be endangered.

* Guy's Hospital Reports, vol. ii. p. 366.
† British Medical Journal, October 30, 1869, p. 475.

There are four instruments in use for the operation of thoracentesis,—the Bowditch syringe, the aspirator, a part of which consists of a trocar and canula, the trocar and canula, and the lancet or bistoury. The second and third are considered best adapted for the purpose, because of the less probability of air entering the pleural sac. If this be a desideratum, the aspirator of Dieulafoy, or its modification by Potain (see Fig. 52), is decidedly the best instrument; and in cases of hydrothorax following acute pleurisy, or where there is reason to believe the inflammation has subsided, it should have the preference. The instrument is used in the same manner as directed in tapping a cold abscess.

Should the operator not be provided with this ingenious instrument, he may use one which I devised for this purpose, consisting of a canula and trocar with a stop-cock, and a gum bag or bottle having a nozzle at one extremity fitted to the end of the canula, and at the other a stop-cock, by which it can be emptied when filled.

Fig. 227.

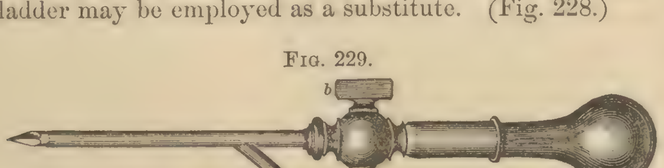
a, canula; *b*, trocar; *c*, gum bag, attached at one end to the stop-cock, *d*, of the canula, and having at the other extremity a stop-cock also.

In the operation the instrument should be thrust through the parietes into the chest, a small puncture through the integument having been first made to facilitate its passage. (Fig. 227.) The entrance into the cavity of the pleural sac having been effected, the nozzle of the gum bag must be immediately fitted into the canula. Should the fluid not flow freely into the rubber receptacle, the instrument may be converted into an aspirator by first closing the stop-cock between the canula and gum bag and opening the one at the other extremity of the latter. If the bag be now compressed with the hand, so as to expel all its air, and the stop-cock then closed, a vacuum is produced, which, the moment the cock connecting with the canula is opened, causes the thoracic accumulation to rush in and fill the bag. By the repetition of this process the fluid may be drawn out by suction. In the absence of the rubber bag a bullock's or hog's bladder may be employed as a substitute. (Fig. 228.)

Fig. 228.

Tapping the chest with the trocar, canula, and bullock's bladder.

Fig. 229.



Trocar for puncturing the chest.

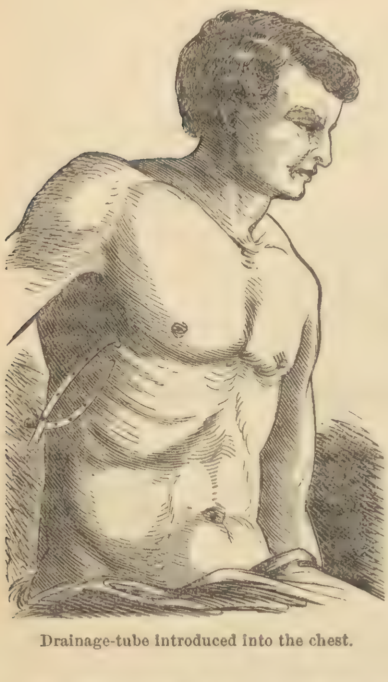
There is a modification of the trocar and canula which is more convenient for tapping the chest than the one just described. The canula is furnished

with a branch (*a*). and a stop-cock (*b*) between the latter and its outer extremity. (Fig. 229.)

In using this instrument, slip over the branch a piece of gum tubing, allowing the free end to rest in a basin or other vessel containing water. After making the puncture in the usual manner, withdraw the trocar, and immediately turn the stop-cock, shutting off all communication with the external opening of the canula, when the fluid will pass through the tube into the water, thus preventing the entrance of air. When the fluid begins to flow less freely than at first, pressing the sides of the lower part of the thorax together will serve to force it out; a voluntary cough on the part of the patient will effect the same object, or a change of posture from the sitting to a semi-recumbent or recumbent position, or turning upon the affected side. Immediately on withdrawing the canula the opening should be closed with an adhesive strip, over which should be applied a compress, secured with an additional plaster.

I am convinced that too much importance has been attached to the admission of air into the chest, and that the precautions employed to prevent this occurrence are in chronic accumulations unnecessary. In cases of chronic sero-purulent accumulations it will be proper, after tapping, to introduce a drainage-tube, in order that the pleural sac may be kept drained until a cure is effected: this obviates the necessity of repeating the tapping. The best drainage-tube is made of rubber, and is perforated with holes.

Fig. 230.



Drainage-tube introduced into the chest.

In performing the operation, make an incision close to and parallel with the upper border of the proper rib, dividing the different layers of tissue until the cavity of the pleura is opened; then, passing one end of a stout thread through the eye of a needle similar to that used for ligating the intercostal artery (see Fig. 224), fasten to the other end of the cord a gum-elastic drainage-tube. Introducing the needle into the incision, carry it upwards around the rib, making the point project beneath the integuments at the upper border of the rib above; then cut down upon its extremity, disengage the thread from its eye, remove the needle, and pull the drainage-tube into position, when, to keep it from becoming displaced, the ends may be tied together. (Fig. 230.) The fluid will be drained away as it accumulates.

Mr. Skerritt,* Physician to the Bristol General Hospital, uses the Lister antiseptic dressing when performing this operation. This consists in placing the instruments in carbolated water, making the puncture under the antiseptic spray, and dressing with oakum and rubber tissue which have been well carbolized. When the dressings are renewed, which for the first few days should be twice and afterwards once a day, the spray and other details belonging to the antiseptic method must be faithfully carried out.

If the case does well, the drainage-tube may be removed at a period varying from two to four months. Occasionally, after puncturing the chest, a quantity of blood discharges with the purulent matter. This sometimes continues,

* British Medical Journal, July 22, 1876, p. 110.

so as to create uneasiness on the part of the patient's friends. I have never seen it prove serious, and believe that it is due to the rupture of the delicate vessels which exist in the thickened pleuræ, just as they are found in the walls of an abscess, and which give way in consequence of the removal of pressure. The use of injections into the cavity of the pleura, after tapping, has been advocated by some practitioners. The tincture of iodine, and solutions of carbolic acid and of permanganate of potash, are the articles recommended. Except in very obstinate cases, their use is of doubtful propriety.

Fistulæ of the thorax.—Openings made into the cavity of the chest, either from gunshot or by operation, may refuse to heal and remain as fistulæ. It will be found, in such cases, that a sac exists some distance below the external opening, in consequence of failure in the pleuræ to unite. A fistula may be due to necrosis of a rib. Injections for the relief of such conditions are useless. The proper course is to establish another opening at the bottom of the sac and introduce a drainage-tube, after the manner described in treating empyema. If the fistula depends upon a diseased rib, the latter should be excised.

Mediastinal Wounds.—It is possible for the mediastinum to be penetrated and yet its contents escape injury. Even a body so large as the shaft of a carriage has passed through the anterior mediastinum without injury to any organ within the chest; and numerous examples of balls and sabres traversing this space have been furnished by authors, in which no damage was sustained by the contained organs. There is, however, danger of pericarditis, pleuritis, and abscess succeeding such injuries. The most important constituents of the mediastinal space are the heart, surrounded with its pericardium, the great vessels which proceed from its base, the descending aorta, and the œsophagus, with the pneumogastric nerves.

The pericardium, heart, and its vessels.—These parts are frequently damaged by concussions, by punctured, incised, lacerated, and gunshot wounds.

Symptoms.—A severe concussion of the chest will often produce a feeble, irregular action of the heart, accompanied by dyspnœa, pallor, and extreme weakness.

The pericardium may occasionally be wounded without the heart participating in the injury. When the vulnerating body, like a needle, remains in the membrane of the pericardium, or lies loose in its cavity, as sometimes happens with balls, the danger is necessarily enhanced, not only from the pericarditis and consequent effusion, but also from injury to the heart. The signs of a wounded pericardium are very ambiguous. The pericarditis which ensues may be expected to furnish the peculiarly localized friction-sound, and after effusion an extended area of dull percussion, with perturbation of the heart's action; but to affirm with certainty the existence of an uncomplicated wound of this membrane, after an injury of the chest, is scarcely possible. During the War of the Rebellion a number of such cases were recorded. The symptoms were pain, dyspnœa, and delirium, but in some of the cases the lung participated in the injury, and may have been as influential in producing these phenomena as the pericardial injury.

Wounds of the heart, though among the most dangerous of all injuries, are not in all cases necessarily fatal.

Symptoms.—The signs which indicate a wound of the heart are not uniform. Syncope, deadly pallor, and a scarcely perceptible pulse, with a cold perspiration, are among the most common, and follow as a result of the escape of blood into the pericardium, compressing the heart. Should the wound be small, or in a direction in which the muscular fibres of the heart are not cut transversely, thus avoiding retraction or gaping, or where a clot closes the orifice, these signs may not appear immediately, but gradually. In addition to these there may be thirst, dyspnœa, anxiety, fear, and pain, though this last symptom is said to be more common in wounds of the pericardium than in those of the heart. A singular convulsive movement of the muscles of

one foot was noticed by Dr. Keen,* an hour and a half after death, in a case of laceration of the heart. These sometimes involved the entire foot, at other times the great toe, and occasionally all the toes.

In the 452 cases collected by Dr. Fisher,† death was immediate in 104 instances, and in 276 took place at periods varying from one hour to nine months. Of the 452 cases there were 72 recoveries. In 36 of these the fact of a previous wound of the organ was verified by an examination held long after the injury, and this is fair ground for supposing that the remaining 36 had been properly diagnosed. Of these 72 cases, 10 were punctured, 43 incised, 12 gunshot, and 7 lacerated wounds. They were distributed as follows: 50 were wounds of the heart, and 22 were wounds of the pericardium. The vulnerating bodies inflicting the injury to the heart, and producing punctured wounds, were needles in 8 cases, and a stile and thorn, each, in 1 case. Those producing incised wounds were knives in 10 cases, daggers in 7, poniards in 2, a bayonet in 1, and in 10 the implements were uncertain; 7 were caused by gunshot, in 4 of which the balls remained; and 3 were lacerated and ruptured. Of the 22 wounds implicating the pericardium, 13 were incised, 5 gunshot,—in 1 case the ball remaining in,—and 4 lacerated and ruptured. The same author notices the relative frequency with which the different portions of the organ were wounded. In 123 instances it was the right ventricle, in 101 it was the left ventricle; the right auricle was injured in 28 instances, the left in 13, and the apex of the heart in 17. In all wounds inflicted in front, the right ventricle is most exposed, forming as it does so large a portion of the heart presenting anteriorly. This greater frequency with which the right ventricle suffers has been still further corroborated by the statistics of Ollivier,‡ who, in an article upon the heart, and in a collection of 61 cases of wounds of that organ, found that the right ventricle was implicated in 29, the left ventricle in 12, and both ventricles in 9 instances. In the same collection the right auricle suffered in 3 cases, the left auricle in 1 case, and in the remaining 7 the wounds were divided between the base and the apex of the organ. Very much to the same purport is the analysis of M. Jamain.§ Of 121 cases collected by this author, 43 were wounds of the right ventricle and 28 of the left ventricle. The duration of life after the infliction of fatal heart wounds differs very much in different cases.

Prognosis.—In most cases death is instantaneous, or at least occurs in a few moments, the patient only uttering an exclamation or giving a few convulsive gasps. In some instances life has been prolonged for several weeks, and in a few, despite the fearful nature of the accident, recovery has taken place.

Dr. Purple‖ records 42 wounds of the heart which did not prove immediately fatal. In the case of Pool, reported by Carnochan, of New York, the patient survived eleven days with a bullet imbedded in the apex of the heart. Dr. Randalls has narrated the case of a negro boy who lived sixty-seven days with a number of shot in the substance of the heart, and a still more remarkable instance is furnished by Ferrus, in which a patient lived twenty-one days with the heart transfixed by a skewer. A curious case is related¶ of a patient who survived three weeks with a watchmaker's file in his heart, the tool having passed through the left ventricle and the right auricle. Hennen** gives the history of a patient from the Royal Hospital at Haslar, who received a bayonet wound through the colon, stomach, diaphragm, lung, and right ventricle, and yet survived the accident nine hours. Chastenet,†† a

* Transactions of the Pathological Society of Philadelphia, vol. v. p. 94.

† Ueber die Wunden des Herzens und des Herzbeutels, Archiv. f. Klin. Chir. von Langenbeck, B. ix. p. 571, 1868.

‡ Dictionnaire de Médecine, 1834.

§ Thèse de Concours, etc., vol. viii., 1857.

‖ New York Journal of Medicine, May, 1855.

¶ Répertoire d'Anatomie et de Clinique Chirurgicale.

** Hennen, Military Surgery, p. 404.

†† Journal de Médecine Militaire, vol. ii.

military surgeon at Lisle, mentions a case of bayonet wound of the right ventricle in the person of a soldier who lived ten days after the injury, and died, as he believed, from mortification of the extremities, the wound in the pericardium and heart having cicatrized, as was shown at the post-mortem examination of the body. Fournier* gives an instance of a soldier who was shot through the breast; a great flow of blood immediately followed, and the man was thought to be dead. He, however, gradually rallied, and in three months recovered, but suffered for a long time from palpitation. Three years afterwards he died from another cause, when the ball was found buried in the apex of the heart.

Four cases of gunshot wounds of the heart not proving immediately fatal are recorded in the Surgical History of the War of the Rebellion,† one of which lived fourteen days after a shot-injury of the right auricle. In the same work is recorded the case of Private John Reynolds, a Michigan sharpshooter, who was shot in the left breast at Spottsylvania, Virginia. At the necropsy, held two years after, the evidence of a previous wound of the right auricle was discovered. A distinct cicatrix was seen, from the effect of which a rupture of the cavity took place, which was followed by instantaneous death.

Mr. Poland‡ alludes to the case of a lad, reported by David and Stewart, who lived five weeks with a piece of wood in the right ventricle of the heart. Velpeau§ mentions the history of a person who received a stab in the left side. The symptoms which followed were of such a nature that at the time the heart was supposed to have been pierced. Nine years after, the man died from causes altogether independent of the previous injury. The autopsy established the truth of the former diagnosis, as the cicatrix of the wound was found in both the pericardium and the right auricle.

That bodies of different kinds may find their way into the heart and pericardium of man and other animals, and remain for a long period without creating any trouble, has been frequently exampled by different authors. Haller‖ gives an instance of a needle, and Hennen of a pin, found in the heart of a bullock. I once saw a nail imbedded in the heart of a bullock, which doubtless had remained for a considerable time in the organ, as the metal was quite corroded by oxidation. Professor Gross has in his possession a pericardium, which contains an encysted needle two inches in length, taken from a man twenty-two years of age, and which gives evidence of having been long a harmless intruder in its present locality.

Treatment.—The patient must be kept in the recumbent position, with the head low, in order to prevent fatal syncope from brain anæmia. External warmth should be applied to the extremities and along the spine, and opium administered to allay pain and quiet fear and nervous restlessness. The hope of the surgeon must rest upon the continuance for some time of a condition approaching collapse, by which the power of the heart will be greatly weakened and the stability of a clot more assured. If signs of dangerous reaction set in, the tincture of veratrum viride should be employed to restrain the action of the organ. Should life be prolonged, and subsequent inflammatory phenomena arise, reliance must be placed upon blisters, opium, and heart sedatives.

Hydrops pericardii.—I believe that dropsy of the pericardium rarely follows wounds either of this sac or of the heart. Hennen¶ mentions a single case, in which eight ounces of serum were found in the pericardial sac. Pericarditis, attended with transudation of serum, however, will frequently follow other wounds and contusions of the chest, and may also arise from rheumatic and other inflammations, as well as from organic disease of the heart.

* Dictionnaire de Médecine, 1834.
† Surg. vol., p. 528.
‡ System of Surgery, vol. ii. p. 606.
§ Traité d'Anatomie Chirurgicale, tom. i. p. 604, 2d éd.
‖ Bibliotheca Chirurgica, vol. ii. p. 378.
¶ Military Surgery, p. 413.

The symptoms of effusion are pyramidal dullness, and feeble cardiac sounds, most distinct towards the upper part of the sternum. In the early stage of such accumulations, and when they are the result of chronic inflammation, friction-sounds may be recognized. When the collection becomes large, there will be irregularity of the heart's action, a feeble, irregular pulse, and great anxiety and distress in breathing, accompanied with a certain degree of fullness of the parietes of the chest over the region of the heart. The diagnosis should, where the case becomes one of extreme urgency and involves the question of operation, be verified by the use of the exploring-needle.

Tapping the pericardium was first performed in America by Dr. John C. Warren in 1852. This was a successful case. The proposal to open the sac dates back to the seventeenth century, though its execution, so far as is known, was not accomplished until 1819, by Romero, of Barcelona.

There is a difference of opinion as to the proper place for making the puncture, some advising the space between the fourth and fifth ribs, some the one between the fifth and sixth, and others—among them Larrey—the one between the seventh rib and the ensiform cartilage. Looking at the subject simply from an anatomical point of view, the space between the sixth and seventh ribs, one inch to the left of the margin of the sternum, would appear to be the most accessible route to the cavity of the pericardium, remembering that the internal mammary artery lies a little external to the side of the sternum and the intercostal at the lower margin of the rib. As in abscesses, the prominence of the swelling should have due weight in determining the place of puncture, as the presumption is that the cavity can be reached most safely where the bulging is most marked. The resistance which the skin offers to puncture should be removed by a preliminary incision with a bistoury, through which the trocar should be passed and pressed cautiously onward until there is reason to believe that the pericardium has been perforated, when the stilet should be withdrawn. If no fluid escapes, the trocar must be inserted and carried farther inwards until the collection is reached. To prevent air from entering, a piece of gum tubing can be slipped over the canula and its end dropped into a basin of water. The aspirator may be more advantageously employed for the purpose of tapping.

The results of the operation will be determined in a great measure by the cause of the dropsy. If it arise from organic disease of the heart, the relief, of course, can only be of a temporary nature. Of the 22 cases collected by Günther, 7 proved successful, 4 died, and in the remainder the result was not obtained.

Dr. John B. Roberts, of Philadelphia, has published an analysis of 41 cases of paracentesis pericardii. Of this number "27 were males, 8 females, and in 6 the sex was not known. The age of the patients was as follows: 11 cases were under 21 years, 15 were over 21, and in 15 the age could not be determined. The oldest person operated on was sixty-eight years of age, and was tapped twice, once on the right side of the sternum; the youngest was six years old, and was also tapped twice. The result of these operations is extremely encouraging: 19 of the patients recovered, 21 died, and 1 case remained uncertain as to its termination, yielding 46.34 per cent. of recoveries."*

The operation has, I believe, been performed only once in this city, and that by Dr. Herbert Norris. The patient did not recover. A noticeable feature in this case, I am told by the doctor, was the existence of violent movements imparted to the canula by the heart.

Wounds of the vessels of the thorax.—Wounds of the internal mammary and intercostal arteries have already been considered. Wounds implicating the great vascular trunks contained in the chest are generally quickly fatal, and yet in some rare cases the prolongation of life for a short period of time, in consequence of pressure upon the injured vessel by fragments of bone, balls,

* New York Medical Journal, December, 1876.

clothing, etc., should be incitement enough for the surgeon to make an effort, hopeless though it may seem, for the rescue of a dying man. Even a wound of the aorta may not prove immediately fatal; and one case is recorded in which recovery followed this accident. This is the case of Heil,* in which the patient lived a year after a wound of the ascending aorta, and died from another disease. Pelletan records the case of a man who lived two months after a puncture of the aorta near its origin,† and Saviard that of another, who survived the wound eleven days. Acting Assistant Surgeon Piper‡ furnishes the notes of the case of a private, accidentally shot by a pistol-ball through the arch of the aorta, who lived long enough to be carried from the place where the wound was inflicted to the post-hospital, a short distance off. Acting Assistant Surgeon White§ also met with an instance of a punctured wound of the aorta, near its root, in which the patient died on the day of its reception.

Wounds of the cavæ terminate fatally, though death is not in all instances instantaneous. Acting Assistant Surgeons White and Horton‖ each report a case of a wound of the descending cava, the first caused by a pistol-ball, the patient living long enough to be carried to a convenient post-hospital; the second produced by an arrow, and which did not prove fatal for forty hours.

Wounds of the innominate vessels.—In two instances where the innominate artery was wounded, one lived twenty-four hours and a second six days. How much longer this last case might have survived it is impossible to say, inasmuch as death was brought about by an attempt to extract the ball, in doing which a furious hemorrhage was provoked, destroying the patient.¶

Wounds of the subclavian vessels.—A wound of these vessels, though in all probability fatal, is not utterly hopeless. Five cases are reported during the War of the Rebellion,** which demanded surgical interference, the patients living from two to sixteen days, and in one of which a Confederate surgeon successfully tied the left subclavian.

One of these cases illustrates very forcibly how a ball may not only wound a large vessel, but may also at the same time obstruct its canal in such a manner as to prevent a fatal bleeding. It was the case of a private belonging to the Sixteenth Pennsylvania Cavalry, who was admitted into the Satterlee Hospital, August 26, 1864, with a gunshot fracture of the clavicle, first rib, and scapula. There was no pulse at the wrist, and both sensation and motion were wanting in the arm, on the injured side. On September 1, several spiculæ of bone were removed from the wound. Six days after, hemorrhage occurred, when an unsuccessful attempt was made to ligate the subclavian. The patient shortly after died, and on making the autopsy the subclavian was found both pinned and plugged with spiculæ of broken bone for two inches of its course.

Treatment.—In wounds of the large blood-vessels of the chest, when life is not immediately extinguished by hemorrhage, the duty of the surgeon is to disturb the patient as little as possible. If moved into a hospital or other place of shelter, it should be done on a stretcher, in the gentlest manner possible, keeping the head and shoulders low, applying external warmth, and giving little heed to collapse. All attempts to explore the wound or to search for the foreign body are of secondary importance, especially if there is reason to believe that the missile is acting the part of a tampon. Assistants should be instructed what course to adopt in case of renewed bleeding, and if the vessel is accessible, as the subclavian or the innominate, a cool, decided, and persistent attempt should be made at ligation. No patient should be allowed to perish unhelped. If there be but a single ray of hope coming from out the light of past centuries of surgical history, let the sufferer have the benefit of it, and the surgeon's efforts cease only when death has decided the conflict.

* Henke, Zeitschrift, 1837.
† Clinique Chirurgicale, 1810, t. iii. p. 241.
‡ Circular No. 3, Surg. Genl. Office U. S. A., p. 35.
§ Ibid., p. 99.
‖ Surgical History of the War, Part I. vol. ii. p. 520.
¶ Ibid., p. 521.
** Ibid., p. 521.

Wounds of the Œsophagus in its thoracic portion are very rare. During the War of the Rebellion no cases of such injuries, so far as I can ascertain, were observed, save one by Assistant Surgeon J. C. McKee, that of a private belonging to the Fifteenth New Jersey Volunteers, who was shot in the chest by a conoidal ball at Spottsylvania. After death the œsophagus was found lacerated by the missile, which remained in contact with the tube. There were no symptoms to indicate the nature of the injury. The only sign which would indicate the existence of such a wound would be the escape through the external opening of fluids taken by the mouth. Holmes notices a case, taken from Boyer's "Treatise on Surgical Maladies," produced by a bayonet-stab in the chest, through which were discharged different materials swallowed. This patient ultimately recovered. The treatment of a case of this nature will consist in sustaining the patient by nutritious injections of milk and beef-essence thrown into the bowel for several days, until there has been time for union to take place.

Wounds of the Thoracic Duct must be not only fatal, but also among the rarest of surgical injuries; and it is difficult to conceive of such an accident's occurring without the participation in the damage of contiguous parts.

WOUNDS OF THE ABDOMEN.

Wounds of the abdomen are divided into *non-penetrating*, *penetrating*, and *visceral*.

Non-penetrating Wounds are subdivided into *tegumentary* and *musculo-tegumentary*, and may, in their origin, be contused, incised, punctured, lacerated, or gunshot. The frequency of abdominal as compared with other gunshot wounds, Otis found to be in the ratio of 3 to 8; and he adds that about one-tenth of all who perish in battle die from injuries of the abdomen.

Contusions of the abdominal walls are quite common, and are the result of blows, falls, the passage of wheels, and pressure between opposing forces. They are characterized by discoloration or ecchymosis, presenting all shades of color,—blue, purple, yellow, and green. These marks are due to the rupture of vessels, chiefly veins; yet the branches are small, and, being situated in the subcutaneous cellular tissue, their rupture produces little inconvenience. Occasionally, especially in the lumbar region, blood-swellings form of considerable magnitude. There is another ecchymosis of much greater importance. It is preceded by a diffused swelling, the discoloration not reaching the surface until after three or four days, and, when present, follows injuries at the lower and outer portions of the abdominal parietes. This condition implies a lesion of deeper and more important vessels, such as the deep circumflex iliac. If neglected, sad structural havoc will be committed by the extensive separation of the planes of muscular tissue in which the blood is situated. In the case of a young boy who was under my care in the Pennsylvania Hospital, who had received an injury on the left side of the abdomen, I found this condition to exist to a very unusual degree. These extravasations may result in abscess, which, if deep, will be of a diffused or non-circumscribed nature. Peritonitis may likewise follow even slight contusions.

The prognosis in contusions of the abdominal parietes is not unfavorable, unless there is reason to suspect deep hemorrhage, the formation of abscess, or peritonitis, any one of which adds greatly to the danger of the case.

Treatment.—When the contusion consists of a slight ecchymosis, nothing more than a stimulating application, such as soap liniment, will be required, in order to quicken the absorption of the changed blood. Should a blood-tumor result, it must not be opened, unless it provokes an abscess: pressure alone, by adhesive strips or by a bandage, will contribute to its removal by absorption, though the process may be slow. After a blow above the crest of the ilium, should there be a diffused swelling, the case must be watched with the most scrupulous care. The introduction of a grooved needle will determine its nature, and if it proves to be blood and continues to increase, a free

incision should be promptly made, for the double purpose of evacuating the accumulation and securing the wounded vessel. When suppuration follows contusions or blood-clots, a free incision will be equally imperative.

Incised and Punctured Wounds.—There are several degrees of these wounds, founded upon their depth. They may extend through the integument and superficial fascia, through the muscles and aponeuroses to the peritoneum, or through all the laminæ into the cavity of the abdomen. Transverse wounds will gape more than vertical ones. They are produced by knives, razors, daggers, sabres, bayonets, horns of animals, etc. When not deeper than the subcutaneous tissue, the bleeding is usually insignificant, as the pudics, superficial epigastric, and superficial circumflex iliac vessels are small. An exception to this statement must be made in case the spermatic cord be injured. I have seen a troublesome bleeding follow a wound of the spermatic artery. When the muscles or aponeuroses are divided, the wound assumes greater importance. The deep epigastric, circumflex iliac, and mammary are liable to be severed or torn, and are capable, under such circumstances, of giving rise to a dangerous hemorrhage. When these wounds are extensive, and situated in the median line (linea alba), or above the crest of the ilium, in front of the erector spinæ muscles, they are likely to be followed by such weakness in the walls of the abdomen as strongly to predispose the patient to hernial protrusions. Their proximity to the peritoneum increases likewise the risk of inflammation of that membrane.

Treatment.—The arrest of hemorrhage will demand the first attention of the surgeon. If the wound is not deeper than the superficial fascia, little blood will be lost, and perhaps no vessels will require the ligature; though no branch which shows a disposition to bleed should be allowed to remain untied. When the muscles are involved, the greatest care must be observed to discover and secure any artery which has been injured; and on this account there should be no haste in closing the wound, especially when it is situated in a locality where a principal trunk of the parietal vessels is situated. If, regardless of this maxim, the parts be sewed together, we may have the mortification to find the muscles separated from one another by blood, with all the concomitant evils. I have seen a patient almost moribund from an oversight of this kind. When compelled to reopen such a wound, there will be difficulty in finding the vessel and a strong probability of subsequent abscesses and even sloughing. Six cases of fatal hemorrhage from wounds of this kind are noticed in the "Surgical History of the War," in one of which a final resort was had to ligation of the external iliac, without success. It will be best to tie both ends of vessels which are found bleeding, enlarging, if necessary, the wound for that purpose. It is possible, where the wound extends into the muscles, to have interstitial bleeding without any blood flowing externally, a fact which should place the surgeon upon his guard against such a contingency. When the hemorrhage has been arrested and all matters foreign to the parts have been removed, the wound should be thoroughly sprayed with carbolic acid and water, and its edges brought together by interrupted silver sutures, inserted sufficiently deep to include all the divided structures. This direction must be faithfully observed, otherwise the retraction of the muscular fibres will greatly weaken the parietes. This deep stitching has been thought by some to be unnecessary, because, they say, the threads soon cut through the included muscles. If, however, a sufficient hold is taken, this will not follow until a bond of connecting material has been provided. The most difficult region in which to secure union is the epigastric. The sparse amount of connective tissue renders the skin less extensible and more prone to gape. After the closure of the wound and its protection by carbolated gauze and rubber tissue or by a water pledget, a soft compress should be placed over the dressings and the abdomen surrounded by a broad bandage, its walls being relaxed by raising the shoulders of the patient. Rest in the recumbent position, a restricted diet, and opium if pain is present, constitute the remaining treatment. If the wound is quite small,

and not deeper than the integument, after its closure we may be content with a compress kept in place by one or two adhesive strips.

Penetrating Wounds.—Two varieties of penetrating wounds of the abdomen are recognized: one without and one with the escape of a portion of the viscera. The peculiar structural arrangement of the abdominal walls—that is, the planes of muscular tissue running in different directions, downwards, upwards, and transversely—admits of the abdominal parietes being incised to a considerable extent and yet no visceral protrusion following, as some of the muscular fibres will always remain undivided and will immediately close over the opening on the withdrawal of the vulnerating instrument. In other instances, even when the opening is quite small, a portion of intestine or omentum will press its way through. In such cases the wound will generally be located in the linea alba or near to the linea semilunaris, where the tendinous or aponeurotic structure prevails.

Whether with or without protrusion, penetrating wounds are fraught with danger, from the consequent risk of peritonitis. It is true that traumatic peritonitis, like traumatic pleuritis, has no great tendency to become general, but is usually circumscribed or limited to the vicinity of the wound, and is not likely to exceed the legitimate demands of repair. When it transcends this it is probably due to an accumulation of blood or pus acting the part of an irritant. These two elements of evil cause much of the surgeon's anxiety.

Though it is exceedingly rare for the viscera to escape injury in penetrating wounds, yet there are some very remarkable cases in which it is believed that not only balls but even sabres have passed through the abdomen without damaging any portion of its contents. While the possibility of such an occurrence is not to be denied, there can be little doubt that many so recorded are without sufficient evidence to justify their being accepted as trustworthy. Dr. Hare,* of New Hampshire, relates the case of a boy, fifteen years of age, who, in sliding from a hay-mow, came in contact with a barbed hay-hook, which entered the perineum, passed obliquely beneath the pubis, and emerged at a point two inches below the umbilicus and one inch from the right side of the linea alba. The hook being separated from the handle, the two parts were removed. In three weeks the patient was well. A still more remarkable example of a penetrating wound is given by Dr. Houston,† the nature of which was clearly established by an autopsy sixteen years after the injury. The case was that of a woman, who, in slipping down from a hay-mow, struck upon the handle of a pitchfork, which, entering the vagina, passed through the pelvis and abdomen in the midst of the viscera, perforated the diaphragm, and, after traversing the chest, struck against the second rib. The handle was removed and the patient recovered. The opening in the diaphragm did not heal; and when the examination of the body was made, a portion of the abdominal viscera was found in the chest, a fact which explained the peculiar gurgling sounds that were often heard in the thorax during the life of the woman.

Penetrating wounds with protrusion.—The degree of protrusion will be determined by the extent of the parietal wound. The omentum, from its extent, and the small intestines, from their mesenteric attachment, having the greatest latitude of movement, are peculiarly prone to escape. I have seen large portions of the bowels force themselves through a very small aperture in the abdominal walls. These accidents not unfrequently follow fights in which one or other of the parties is cut with a knife.

Treatment.—When the case is one of simple protrusion, without intestinal or omental injury, the parts should be returned into the abdomen with the least possible delay. It should not be forgotten that every moment the viscera remain outside of their normal cavity exposed to the air, the danger of inflammation is increased. It is not uncommon in wounds received in street encounters to find the parts soiled with dirt and particles of gravel,

* Boston Medical and Surgical Journal, vol. xxii. p. 71. † Ibid.

All such matter must be carefully removed by the douche. The water should be warm, and may be applied by being squeezed from a sponge or thrown from the nozzle of a syringe. It is not always an easy task to restore the protruded structures. They may be constricted by the edges of the wound and refuse to recede. Under such circumstances the body should be bent or flexed so as to relax the parietes and admit of the widest separation of the opening. To secure the full value of this position, either the fingers or retractors should be inserted on each side of the wound and the walls of the body be well drawn forward. Should the difficulty consist in the intestines being distended with gas, the gut must be gently compressed between the thumb and finger, in order to force the air into that part of the bowel which is within the abdomen; if successful, the collapsed tube can be readily replaced. The gas may be removed also by making minute punctures in the intestine with a needle, though the practice is not to be commended. If these different plans fail, the wound should be enlarged with a probe-pointed bistoury, the intestine at the same time being guarded by the fingers against injury.

Where the wound is large, and when several coils of intestine have escaped and become filled with air, much difficulty is often experienced in consequence of the involuntary efforts of the patient extruding them as often as they are returned. The remedy in such cases is the use of an anæsthetic preliminary to efforts at reduction. On returning the prolapsed viscera, the omentum should have precedence of the intestine, when both are present. If reduced together or in mass, there is danger of the bowel becoming so entangled in the folds of the omentum as to create obstruction or strangulation. This was the case in two instances which I can recall.

It is worthy of notice that the intestines in being restored are sometimes forced between the parietes and the reflected peritoneum, an error which may be readily committed, and which is best avoided by following the receding mass with the fingers and ascertaining in this way that the wound is entirely clear of obstruction. Should a portion of the omentum be strangulated in the wound for some time before application is made for relief, it will in all probability be found adherent to the circumference of the opening, and perhaps its vitality destroyed. Whether this last be the case or not, it will be obviously improper to attempt its reduction. Such adhesions cannot be broken up with impunity, and if this were done, to restore a mass of deteriorated structure after so long a sojourn outside of its normal cavity would be only to cast a firebrand into the abdomen. The protruded portion should be surrounded with a ligature on a level with the parietes, and the mass cut away, allowing the stump to cicatrize in the wound. I have removed large portions of the omentum in this way with entire success. After the reduction of the intestines the wound must be carefully examined, and any vessels requiring ligature are to be secured. Next in order is the closure of the divided parts; and here the rule to include all the structures which have been severed applies with increased force. It was some time before I could accept this method, believing that the peritoneum was so resentful of irritation that the prick of a needle must tend to kindle inflammation; but I have long since learned better, and now know that to neglect its inclusion with the other components of the abdominal walls is to leave the patient exposed to the very evil which it is vital to avoid. The sutures—which should be silver or carbolized catgut—must accordingly be carried through all the layers, including the peritoneum, and in sufficient numbers to bring them accurately together, thus obviating any vacuities that might otherwise remain in the cellular tissue which connects the peritoneum to the parietes, and thereby preventing interstitial extravasation. The additional treatment, including dressings, position, and constitutional management, does not differ from that described under non-penetrating wounds.

Rupture of the abdominal walls without the integument being broken.—This injury is not common, but may exist without lesion of the abdominal contents. The causes which produce such a rupture are falls, the passage of

wheels, tetanus, etc. Professor Da Costa witnessed the case of a cavalryman who, in consequence of a fall from his horse, had the left rectus muscle torn. The umbilicus protruded very much as the effect of the injury. A painter was brought into my hospital ward having fallen from a second-story window upon the pavement. He was restless, pale, cold, and almost pulseless. There was no wound of the integument, but on the left side of the abdomen, a little above Poupart's ligament, there was a marked bulging, very resonant on percussion, yielding a gurgling sound, and which I regarded as a portion of the intestine that had passed through a rent in the broad muscles. A post-mortem shortly after his admission verified the existence of this lesion. Pollard* gives a case of rupture of the rectus muscle in a hospital patient who fell against a bed-post; and the same author thinks that in such instances there may have existed a previous muscular degeneration predisposing to a lesion of this nature. The symptoms of rupture are very much those of internal hemorrhage, though it does not necessarily follow that much blood is lost. The face is pale, the pulse small and feeble, the skin cold and clammy; there is a sense of extreme prostration, accompanied with anxiety, restlessness, and tossing about of the patient.

Treatment.—In order to bring about reaction, external warmth should be applied, and wine or brandy administered internally. I do not attach any importance to the use of milk, beef-tea, or other articles of liquid nourishment. In the condition of shock they are not appropriated, and, lying in the stomach, do more harm than good. Stimulants also remain without being absorbed, and for this reason should be exhibited in small amount and at considerable intervals. Should the patient survive for any length of time, it may be necessary to cut down and restore the intestine. Such an operation would certainly have been demanded in the above-mentioned case which came under my care, had death not taken place early, as the rent had produced strangulation of the bowel. If by position and taxis the intestine can be restored, and retained by a compress and bandage, such a plan should be adopted in preference to an operation; but if not, there is no reason why the skin should not be divided, the constriction relieved, the bowel reduced, and the parts united by deep sutures, which will conduce to establish a stronger bond of union than that which results from cicatrization without sewing.

Penetrating Wounds implicating the Viscera.—Wounds of the Stomach.— The epigastric region is a dangerous locality in which to receive injuries. A blow applied here with much force has frequently been followed by death without, it is said, any appreciable lesion. This is possible, owing to the proximity of the great solar plexus; though I doubt not that, if a careful examination had been made in such fatal cases, in most of them, at least, sufficient visible explanation would have been found for the unfortunate result. I was once called to see a miller who had been thrown violently from a horse, striking the abdomen just below the sternum against the corner of a wall. Though greatly shocked, he was able to rise and walk three-fourths of a mile to his home, where he died in a few hours in an agony of pain such as I have never witnessed in any other case during all my professional life. There was no abdominal distention or tenderness, no marked pallor or moist cold skin, no vomiting or hiccough, nothing indeed to indicate extravasation, hemorrhage, or peritonitis; and yet I cannot doubt that the man had a rupture of the stomach. So dangerous are injuries of this region that even in the pugilistic ring it is considered "foul" to plant a blow below the belt.

The danger is enhanced if at the time of receiving an injury the stomach is distended with food or gas. Dr. Collins† narrates the case of a boy who fell twelve feet shortly after eating a hearty meal, producing a rent two

* Holmes's System of Surgery, vol. ii. p. 629.

† Boston Medical and Surgical Journal, vol. lxxiii. p. 202.

inches long on the anterior surface of the stomach near the pyloric extremity, which proved fatal in nine hours. Mr. Bryant records an instance of rupture of the mucous membrane of the stomach of a child seven years old, produced by a blow when the organ was distended with food.

Rupture sometimes follows the distention of the organ after eating a liberal meal, in consequence of the coats having been eroded from a carcinomatous ulcer. A paper-hanger who had for several years suffered from dyspeptic symptoms, after taking breakfast left his house in his usual health, to enter upon the duties of the day. He had scarcely passed the yard gate when he fell to the ground as though shot by a pistol-ball. On my visit a few hours after the accident, in consultation with his physician, we found him pale, cold, vomiting, and almost pulseless, with distended abdomen, and suffering intense pain. The opinion entertained at the time was that the stomach had been ruptured from cancerous ulceration. The autopsy established the correctness of the opinion. A contusion of the stomach may be followed by a circumscribed slough, the separation of which, several days after the injury, will probably be followed by a sudden and unexpected death.

Symptoms of rupture of the stomach.—The signs which indicate such an accident are extreme prostration, intense pain, and vomiting of blood together with other matters. In the course of a few hours the features shrink, the face assumes a Hippocratic expression, the abdomen becomes tender, the patient lies upon the back, with the thighs drawn up, indisposed to make the slightest movement; the pulse is feeble and frequent, the skin cold and clammy; in fine, all the symptoms of intense peritonitis are present, the scene closing with retching, hiccough, and death.

Incised, punctured, and gunshot wounds of the stomach are generally fatal, though there have been a few instances of recovery, so that we need not utterly despair in such cases. Every one is familiar with the case of Alexis St. Martin, whose stomach, by means of a gastric fistula, has enlightened physiologists so much on the subject of digestion. This man still lives, and enjoys good health at the age of about seventy-three years. Physick* relates the case of a man who was under the care of Dr. Archer, of Maryland, who, shortly after a hearty meal, received a wound of the stomach two inches long, through which passed meat and cabbage. In the absence of medical assistance at the time, a shoemaker sewed up the opening in the parietes. This was subsequently opened, and the patient made a good recovery. Dr. Peters,† of the United States Army, reports the case of Private Bowers,‡ who received a shot wound of the stomach at South Mountain, which wound discharged for two months through a fistulous opening in the abdominal walls, but afterwards healed. No less than nineteen cures of wounds of the stomach were reported during our recent war; but, under the searching criticism of Dr. Otis, these were reduced to the single one of the private above named; and even this is not free from doubt as to the correctness of the diagnosis. Guthrie records several cases of cure of wounds of the stomach. The cause of death after such injuries is extravasation into the peritoneum, followed by shock and exhaustion. It is a curious fact that, in exceptional cases, the contents of the stomach do not escape, although the viscus may be filled with food. Dr. R. K. Smith § saw a wound one inch in length at the cardiac end of the stomach, and, though the organ was full at the time, there was no extravasation or vomiting, though the patient lived twenty-six hours. An occurrence of this kind is probably due to paralysis of the muscular coat, which often follows wounds of the hollow viscera and arrests their movements.

Symptoms.—The signs of a wound of the stomach are shock, pain, abdominal distention, vomiting of blood and other matters, præcordial distress, and hiccough. The least equivocal of these are vomiting of blood, pain, and collapse; and when these are associated with the escape of the contents of the

* Gibson's Surgery.
† Surgery of the War, Part II. vol. ii. p. 42.
‡ Ibid., vol. ii. p. 46.
§ Medical Examiner.

stomach through the external opening, the nature of the accident admits of scarcely a doubt.

The establishment of a fistulous opening very commonly follows, should the patient survive the injury sufficiently long.

Treatment.—In cases of suspected rupture nothing can be done except to palliate: external heat should be applied to the extremities, and opiates freely administered, either hypodermically or by the rectum. If the stomach protrudes, the wound should be sutured and the organ relaxed after the manner described in detailing the treatment of intestinal protrusion. The external opening being closed, as in parietal wounds, the patient is to be kept upon the back, with the shoulders and limbs elevated, and both the general system and the peristalsis of the organ kept quiet by the subcutaneous use of morphia or by suppositories of opium. No nourishment should be administered by the mouth for at least eight or ten days, the patient in the mean time being sustained by enemata of milk, beef-essence, and brandy. The urine should be drawn with the catheter, and no efforts at defecation allowed for ten or twelve days.

Where no protrusion of the organ exists, and yet the evidences of a wound are present, shall the seat of injury be sought after and the stomach be drawn out and sutured? If, on stretching the parietal opening, the wound is discovered, this of course will be the proper practice: even a certain amount of search, made with due gentleness, is allowable. Should the wound of the organ be found lying against the external opening and the contents passing through, it has been debated whether to leave it undisturbed, to stitch it to the margins of the abdominal opening, or to draw it out, sew, and return. When the wound does not exceed one inch in length, and has been seen within twenty-four hours, the viscus should be drawn out, stitched, and restored to its cavity. When much larger, it will be wiser to stitch it to the external opening; and if thirty-six hours have elapsed, it is better to leave it to natural processes, as by that time adhesion between the margins of the wound and the parietes will have commenced.

These injuries are prone to terminate, should the patient live sufficiently long, in gastric fistula. A number of such cases were noticed during the War of the Rebellion. These openings may remain permanent, as in the case of Alexis St. Martin, or gradually close, as in the one recorded by Dr. Peters. When there is a natural tendency to cicatrize, it may be facilitated by occasionally penciling the orifice with a crayon of nitrate of silver.

Rupture of the Intestine.—A blow or fall upon the surface of the abdomen will sometimes produce a rupture of the intestine without any external lesion. The probability of such an accident is increased if at the time of receiving the injury the bowel is distended with flatus. Dr. E. K. Sanborne, of Lowell, Massachusetts, records a case of rupture occurring in an adult, who was struck on the abdomen by the handle of a hand-cart and at the same time pressed against a wall. The man was able to wheel his cart across the yard, but was immediately afterwards seized with intense pain, and died in forty-six hours. The autopsy revealed a rupture extending not only through the entire gut, but also one inch into its mesenteric attachment.

Dr. G. W. Otis witnessed an instance of rupture of the ileum, produced by a blow over the right iliac region from the fist of a fellow-workman, from which the patient died in twenty-four hours;* and another case has been reported by Dr. Cabot,† in which a young man, aged nineteen, was kicked in the abdomen by a horse and died in twenty-eight hours, the jejunum having in it a rupture one inch in length. Instances are recorded in which the peritoneal coat of the intestine has been alone ruptured, either from external violence or from extreme flatulent distention.

When rupture of an intestine takes place, it is followed by extravasation of its contents and by hemorrhage into the peritoneal sac.

* Boston Medical and Surgical Journal, vol. ii. p. 7. † Ibid., vol. lvi. p. 498.

Symptoms.—The symptoms which follow rupture of the intestine are not unlike those which indicate a similar injury of the stomach. These are intense pain, a slow and feeble pulse, pallor, and vomiting. The abdomen, though not swollen, soon becomes tender, and towards the last distended; the features shrink, the face assuming a Hippocratic appearance; the strength rapidly fails, and death usually follows in from twenty-four to thirty hours.

The post-mortem appearances are those of a rapidly-developed peritonitis. The intestines are deeply injected, covered with patches of lymph, their convolutions glued together at different points with plastic matter, and the peritoneal sac containing fæcal matter, and a blood-stained, dirty, or greenish fluid, in which float particles of exudation. Upon opening the abdomen an exceedingly fetid gas sometimes is discharged, a single inhalation of which I have known to induce a degree of poisoning from which the person did not recover for several weeks.

Rupture of the peritoneal coat alone, it is thought, can be diagnosed from that which involves the entire thickness of the intestinal tube. In the former, vomiting is absent; in the latter, it is present: in the former, the patient is exceedingly restless and constantly changing place in the bed; in the latter, the position is a fixed one. The pain is also less severe in the incomplete than in the complete rupture.

Treatment.—When the intestine is torn, little can be done, except to mitigate suffering. Opium, in some of its forms, must be our chief reliance, either given by the mouth, by the rectum, or hypodermically. Hot fomentations will aid in alleviating the distress, and a little brandy-and-milk may be given from time to time. Perforation of the intestine, such as occasionally takes place in enteric fever, may occur, and yet the patient survive. This was certainly true in the case of a prominent surgeon of Philadelphia.

Wounds of the Intestines without Protrusion.—These wounds may be incised, lacerated, punctured, and gunshot. In looking into the abdomen when its anterior wall is opened, and observing how closely the contents are packed together, it would seem impossible that any body should enter or pass through the cavity without inflicting a fatal injury; and yet there are not wanting instances in which it has been traversed without any harm to the viscera resulting. This I can understand when the vulnerating body is blunt; but when it is sharp-pointed, like a bayonet or a sword, or when the missile is a ball, such harmless passage is to me so incomprehensible that I cannot assent to those marvelous cases which are recorded, believing that some error must have existed.

The manner in which the intestines are convoluted or coiled renders them exposed to multiple wounds.

The jejunum and ileum suffer most, in consequence of the large space which they occupy in the abdomen.

Whilst all intestinal wounds are very fatal, those of the large intestine are less dangerous than those of the small. This is due to three causes: first, to the absence in the former, at certain portions, of a peritoneal covering, as in the posterior surface of the ascending and descending colon; second, to fixedness of position; third, to the comparatively solid nature of its contents. The effect of mobility and extensive peritoneal investment is well illustrated by the fact that wounds of the transverse are more fatal than those involving either the right or the left colon. Forty-one cases of wounds of the colon during the late war are known to have recovered. Injuries implicating the caput coli and the descending colon furnished the largest number of recoveries.

Balls and other bodies sometimes enter the intestine and are voided by stool. In most cases it is doubtless the colon into which the missile passes. Dr. Forbes* reported two very interesting cases of this kind. In one a ball entered the chest just above the right nipple, and, from the direction in which

* Transactions of the Philadelphia College of Physicians, 3d Series, vol. ii. p. 183.

it was fired, most probably wounded both the lung and the liver. The patient expectorated a bloody sputum. Eighteen days after, the ball, weighing fifty grains, was passed at stool. The second case was that of a lad who was shot by his companion in the abdomen, the pistol being charged with gravel-stones. Ten days subsequent to the injury, the boy passed four of these stones by stool. Both patients recovered.

Small wounds of the bowel are not necessarily followed by an escape of its contents. Three conditions follow, which offer an obstacle to such a result, viz., a temporary paralysis of the muscular coat; a contraction in the sides of the wound, reducing materially its size, as shown by the experiments of Professor Gross; and a protrusion of the mucous membrane acting as an obturator. In the case of a Ute Indian, who died in my hospital ward from chronic diarrhœa the result of extensive ulceration of the colon, a perforation in the duodenum the size of a quarter-dollar existed, which was so completely closed by the prolapsed mucous membrane that nothing had escaped from the bowel.

The fatality of penetrating wounds of the abdomen is very great. The records of the War of the Rebellion exhibit a mortality of 87.2 per cent., 3031 having died out of 3717 cases, the undetermined cases being rejected. Taking into account all wounds of the belly where the result was ascertained, 3227 died, or 48.2 per cent.; and of those positively known to be intestinal wounds, 9 in every 10 were fatal. The analysis of 3134 flesh wounds yielded a mortality of 25.3 per cent. This is certainly too heavy a death-rate, and is so regarded by Dr. Otis, who explains it as being due to the inclusion in the estimate of 1000 cases the result of which was not known.*

Symptoms.—Among the most constant signs of a wounded intestine with extravasation are meteorism and the passage of blood, followed by pain, peritonitis, a quick and feeble pulse, coldness of the surface, a dorsal decubitus, rapidly failing strength, and hiccough. The escape of fæcal matter externally, which sometimes follows incised wounds, is a still more significant sign; in this case the damaged portion of the intestine generally lies at the opening in the parietes.

Resonance after abdominal injuries must not be regarded as decisive of an intestinal wound. Spinal shock is followed by the same phenomenon, from enfeeblement of the muscular walls of the bowel. After wounds of the abdomen, air may be discovered in the walls as well as in its cavity. There are two ways in which this can occur: first, the air may escape from a wounded bowel, and, in addition to entering the cavity of the peritoneum, may find its way between the parietal peritoneum and the transversalis muscles, spreading through the subperitoneal connective tissue and gradually reaching the subcutaneous tissue; second, the air may enter from without through the external wound, and be disseminated between the laminæ of the parietes. It will be recognized, when so situated, by the crackling or crepitating sensation communicated to the fingers on pressure. Erichsen† mentions a case of emphysema following a puncture of the bladder through the rectum. The air entered the subperitoneal connective tissue, and passed through the ischiatic openings, and down upon the back of the thigh.

Treatment.—The treatment of intestinal wounds without protrusion consists in the administration of a sufficient amount of opium or morphia to subdue pain, to maintain the muscular coat of the bowel in a state of rest, and to insure absolute quiet of the whole body. The use of a little milk after the first thirty hours is allowable, but it should be given in small quantities and at considerable intervals. Should the patient survive, the bowels are not to be disturbed for twelve or fourteen days, and then very gently by a little Rochelle salts. The use of injections must be avoided, for, should the wound be in the large bowel, the distention from their use might endanger the cicatrix.

The propriety of enlarging the parietal wound and seeking for the damaged intestine, in order to unite its edges by suture, and at the same

* Surgical History of the War, Part II. vol. ii. p. 202.

† Erichsen's Surgery, vol. i. p. 560.

time to remove all extravasations, has been suggested by some writers. Professor Dugas, of Georgia, in a paper read before the International Congress at Philadelphia in 1876,* strongly advocated this course. He thinks that death in such wounds is oftener the result of septicæmia than of peritonitis, a conclusion in which I do not concur.

Several reasons may be urged for non-interference in such cases. First, the uncertainty as to the injury sustained by the abdominal contents until the development of those inflammatory changes which no operation could improve; second, the danger of disturbing adhesions which constitute the safety of the patient (the death of Fisk, who was shot by Stokes, in New York, it is alleged was due to meddlesome explorations); and, third, the increased risks of peritonitis by further incision of the peritoneum and by handling the intestines in search of the supposed wounds.

Where, however, the rational signs of a lesion of the intestine are present, such as the appearance of feculent matter in the opening, it would be proper to enlarge such a wound for the purpose of removing either blood or fæces, the presence of which could not fail to excite destructive peritonitis, and in order to suture the injured intestine. Where the surgeon does not see the case until eight or ten hours after the occurrence of the accident, and finds the contents of the bowel discharging through the parietes, any attempt to draw it out, either with or without enlarging the wound, in order to apply sutures, will be improper. It must be left alone, as also the opening in the walls of the abdomen. Even in the short space of a few hours the intestines and parietes will begin to adhere, constituting the chief hope for the safety of the patient.

Wounds of the intestines and omentum with protrusion.—These injuries are more favorable than those in which the wounded bowel does not protrude, as fæcal extravasation into the peritoneum is not so liable to follow, provided the protrusion occurs immediately on the reception of the wound in the parietes, as is the case in most instances. When the resistance of the abdominal walls is removed by an incised wound, the escape is usually with considerable force, not inappropriately termed "gushing out;" and this movement is an important element in determining the intestinal injury, as by it the bowel is pressed against the vulnerating body. Dr. A. R. Kilpatrick, of Woodville, Mississippi, relates the case of an abdomino-intestinal wound in a colored man aged forty-seven years, caused by an axe flying from its helve while in the hands of a fellow-workman, which, striking the abdomen and dividing the recti muscles transversely, inflicted a wound six inches in length. Closely following the falling axe was a hat-crown-full of intestines, consisting of colon, ileum, and jejunum. They remained in this situation for one hour and a half before being seen by the doctor, at which time stercoraceous matter and some melon-seeds were seen passing from the injured bowel. The sound viscera being returned into the abdomen, the wound of the intestine was closed by sutures, both ends of which were brought out of the external opening, and the abdominal wound closed by interrupted sutures. In three days the intestinal sutures came away, and on the eighth day a large quantity of bloody serum and fæces was discharged through the parietes of the abdomen. In twenty hours the wound had closed; and the patient recovered.† This case serves to illustrate the rapidity with which adhesion of the bowel to the walls of the abdomen takes place, thus forming a barrier to surrounding extravasation.

TREATMENT.—If the omentum is injured, the torn vessels must be carefully searched for, each one ligated with the animal ligature, both ends being cut off, and the mass returned. When it is much lacerated, with the certain prospect of sloughing, the mass should be surrounded with a silk ligature, the damaged part cut away, and the sound portion restored to its proper cavity, the stump being secured in the external wound, through which the ends of the ligature are allowed to hang. The extent to which the omentum may be

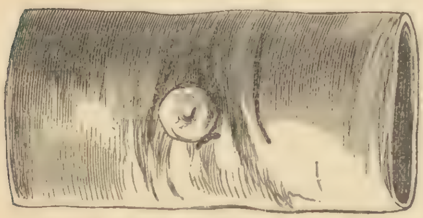
* Transactions. † Boston Medical and Surgical Journal, vol. xxxi. p. 76.

removed is well illustrated in a case related by Dr. J. B. Stanton, of Ellicottville, New York.* A woman aged thirty, seven months advanced in pregnancy, had the abdomen ripped open by the horn of a cow. The intestines protruded in mass, the liver and stomach were exposed to view, and the omentum was so torn that it was removed entire, weighing, it is said, about seven pounds. On the fourth day the woman aborted, the child living only three hours, the patient, however, making a rapid recovery in twenty days.

If the displaced omentum has been allowed to remain in the wound until adhesion has taken place, no attempt should be made to restore it: it must be permitted to slough off, or it may be surrounded by a ligature on a level with the skin and the protruding part cut away.

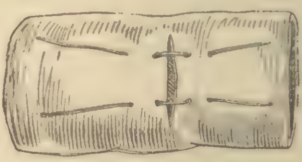
The management of a wounded intestine must be regulated by the extent of the injury. When it is a small puncture, not exceeding one-eighth of an inch, the sides of the opening are to be picked up with a pair of forceps and surrounded by a ligature, as one would tie the mouth of a sack: both ends of the thread are to be cut off. (Fig. 231.) When the wound to be closed

FIG. 231.



Manner of tying a small punctured wound.

FIG. 232.



Lembert's suture for intestinal wound.

is an incised one, a number of variously-formed sutures have been suggested for the purpose, as the glover's, interrupted, Gely's, and Lembert's. The last, or Lembert suture, is to be preferred. It is an interrupted one, and consists in introducing and bringing out a silk thread after the manner shown in Fig. 232. The exit of the needle on one side and its entrance on the other should be three-eighths of an inch from the margins of the wound, the middle suture being first inserted. The distance between the stitches ought not to exceed one-fourth of an inch, and when the requisite number are deposited the ends are to be tied together and cut off close to the knot. The bowel, being sutured, is next restored to the abdominal cavity.

The advantage very justly claimed for this suture is the influence which it exerts in inverting the external coat of the intestine, by which its serous surfaces are brought in contact, thus counteracting the tendency to eversion and the protrusion of the mucous membrane of the intestinal wound, an accident which would greatly delay, if not defeat, the union.

What is the fate of the sutures? Their first effect is to excite a local peritonitis, during which they are covered with an inflammatory transudation, or are temporarily encysted. After this the threads begin to advance towards the interior of the bowel by ulceration, the external wall of lymph preventing the products of the ulceration from coming in contact with the peritoneum. The sutures finally reach the cavity of the intestine, and are passed with the fæces. In the process of healing, the intestine at and around the wound becomes adherent to the surrounding parts, that is, to adjoining loops of the bowel, to the omentum, or to the parietes of the abdomen. After the sides of the wound unite, the redundant lymph is absorbed. The mucous membrane heals slowly, chiefly on two accounts, viz., from contact with the intestinal contents and secretions, and from the disturbing influence of the peristalsis. In cases where the wound in the intestine is a lacerated one and its edges very ragged, and where in all probability sloughing will

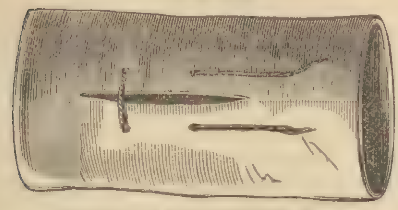
* Boston Medical and Surgical Journal, vol. lix. p. 249.

follow, it is better to trim the irregularities away before closing. After the sutured bowel has been restored to the abdomen, the external wound must be closed by deep interrupted sutures, including the parietal peritoneum, and the parts covered with a piece of lint moistened with carbolated oil.

When the intestine is divided across, all attempts to unite the two parts by introducing the end of one piece into the canal of the other, or by the inversion and abutment of the serous surfaces, the adjustment being maintained by sutures, will prove useless. Under such circumstances the ends of the intestine must be brought into the external wound and made fast to its circumference by passing sutures at several points between the two. An artificial anus is to be expected, which, though a disgusting and distressing condition, is not irremediable.

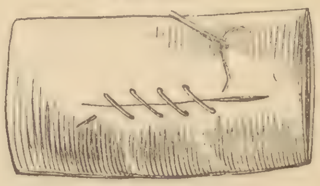
The suture of Gely (Fig. 233), though capable of closing an intestinal wound and at the same time of producing inversion of the serous coat, is

FIG. 233.



Gely's suture for wounded intestine.

FIG. 234.



Glover's suture for closing intestinal wound.

inferior to and more difficult of application than that of Lembert. The glover's suture (Fig. 234) has been employed for stitching incised wounds of the bowel; but the objection to its use is the difficulty with which the serous surfaces are brought together.

The after-treatment of intestinal wounds consists in enforcing absolute rest, the use of opiates in quantities sufficient to control the peristalsis of the bowels, and the administration of a little milk at intervals of three or four hours for the first four or five days, after which the quantity may be somewhat increased, and in two or three days more may be supplemented with a little beef-essence. The bowels should not be disturbed earlier than the fourteenth or fifteenth day, and then by the gentlest laxative, such as a pill consisting of the extract of belladonna with a little rhubarb and aloes, or small doses of castor oil. If the wound is not in the large intestine, an enema will answer in place of the pill.

Wounds of the Liver and Gall-Bladder.—The liver may be ruptured without an external wound, in like manner as are the stomach and intestines. The passage of a wagon-wheel, a grazed shot, a blow, or a fall upon the side are some of the causes which produce this injury. Rupture may affect either surface of the liver: Mr. Bryant thinks the upper is oftener ruptured than the lower. The injury may exist without laceration of its peritoneal coat.

The liver is sometimes wounded by fragments of broken ribs, with or without an external opening. It is also the subject of incised, punctured, and gunshot wounds. The gall-bladder may be wounded in common with the liver, or independent of the latter. It is sometimes opened by ulceration excited by the presence of gall-stones.

SYMPTOMS.—The signs of a wound of the liver are extreme prostration, from hemorrhage (the organ being exceedingly vascular), vomiting, the discharge of bile through the external opening,—when such is present,—jaundice, thirst, and often itching of the skin. The contact of the biliary secretion—whether from the liver or from the gall-bladder—with the peritoneum will excite inflammation of that membrane.

PROGNOSIS.—The prognosis is exceedingly unfavorable. Should the patient survive the loss of blood, there remains the risk of peritonitis, and still later

that of abscess. Should the serous covering of the organ remain intact, the prospect of recovery is enhanced, as the bleeding will be limited in amount, and the peritoneal sac will be saved from contact with either blood or bile. Hennen gives two and Guthrie five cases of recovery after wounds of the liver. Dr. Andrews, of this city, also saw a case in which an extensive wound of this organ was followed by restoration to health.

Dr. Otis, with his usual care, admits thirty-two indubitable recoveries after shot wounds of the liver, twenty-three of which were complicated by injury of the other viscera of the abdomen. A very interesting example of lesion of the liver was under the care of Dr. Morton at the Pennsylvania Hospital. The rupture was nearly five inches in extent, and at the time of the patient's death had almost entirely cicatrized. Few recoveries follow a wound of the gall-bladder. Two such are among the cases of liver wounds reported by Dr. Otis.* Stromeyer records only a single instance in which a patient got well after such a wound.

Treatment.—The treatment consists in giving opium to relieve pain and secure rest. Inflammatory symptoms must be met with the usual antiphlogistic remedies. If the signs of internal hemorrhage are present, wine of ergot with gallic acid should be administered, and absolute rest enforced.

Abscess of the Liver.—This may be the result of a wound or contusion of the organ, or it may arise from dysenteric, miasmatic, or malignant causes. These abscesses open in various directions; sometimes into the duodenum, sometimes into the bronchial air-passages, in rare instances into the œsophagus, but most frequently externally, through the walls of the abdomen. In a case which I once had under my care, the abscess was discharged through a small opening into the œsophagus immediately above the diaphragm. Whatever direction the purulent matter takes, it is generally preceded by inflammatory adhesion of the adjacent parts, so that a dangerous extravasation is avoided. These abscesses are frequently very obscure in their origin, and in their early history are difficult to diagnose.

Symptoms.—The signs of hepatic abscess are, pain in the region of the liver, sometimes dull, at other times lancinating, tenderness over the right hypochondrium, jaundice, emaciation, rigors, febrile disturbance, and perspiration. Cough is not an uncommon attendant, especially if the abscess tends towards the lungs. The external manifestation of the disease is seen in a bulging or prominence of some part of the abdominal walls, when the pus approaches the surface in this direction, generally at the epigastrium or near the cartilaginous extremity of the eighth or ninth rib.

The prognosis in hepatic abscess is unfavorable. A very large proportion of patients perish from exhaustion consequent upon the constitutional irritation which follows the liberation of the pus.

Treatment.—Hepatic abscesses should not be prematurely opened. It is important that the work of inflammatory consolidation between the gland and the walls of the abdomen be thoroughly accomplished, and until this has been effected there is little to be done, except to sustain the patient's strength by proper nourishment and the administration of tonics, such as quinine and aromatic sulphuric acid. When pointing takes place, accompanied by fluctuation, and the skin over the swelling assumes a purple discoloration, the abscess should be opened by making a puncture with the ordinary sharp-pointed bistoury. The pus which comes away is usually mingled with the biliary secretion. Many patients, after the opening is made, rapidly lose strength, and die in two or three weeks.

Wounds of the Spleen are less common than are those of the liver. They are usually punctured, incised, or gunshot injuries, and are generally accompanied by serious damage to other organs in the abdomen. In some instances, where a portion of the abdominal parietes has been carried away by a missile or

* Surgical History of the War of the Rebellion, Part II. vol. ii. p. 148.

has been extensively divided by a sabre or a knife, the viscus has protruded through the opening.

The organ is occasionally ruptured, in consequence of falls, blows, and even by muscular exertion.

Symptoms.—Aside from the presence of an external opening sufficiently large to admit of the organ being seen, there are no symptoms which indicate with certainty the existence of such an injury. When, however, the position of a wound is in the splenic region, and after its reception there is increasing pallor of the countenance, indicating the existence of internal bleeding, there is ground for supposing that the organ has been wounded.

Prognosis.—At one time these injuries were esteemed to be invariably fatal; but, although in a majority of instances death is an inevitable consequence, there are numerous examples of recovery. Larrey and Guthrie have witnessed instances of this, and Hennen's testimony is to the same effect. The accuracy of diagnosis in some of these cases was verified by post-mortem examinations made long after the accidents, in which the cicatrices answering to such lesions were distinctly recognized. Two examples of recovery after gunshot wounds of the spleen, and one after a bayonet wound, are recorded in the "Surgical History of the War."*

Rupture of the organ in consequence of external violence, so far as I am aware, has been invariably fatal. It has been observed that the accident is less likely to provoke peritonitis than when the intestine is wounded, blood being less irritating than fæces.

The fatality following injuries of the spleen is due to hemorrhage, and, notwithstanding its great vascularity, these cases are not so quickly fatal as are those of the liver. The elastic nature of its capsule and of its trabeculæ serves to compress the organ and in this way prevent a very rapid escape of blood.

Exceptional cases occur, in which the patient survives the danger of hemorrhage and afterwards perishes from abscess. Two instances of this kind were observed during the War of the Rebellion.† The inflammation which follows wounds of the spleen, like that following wounds of the liver and lung, is generally local in its character, showing little tendency to become diffused.

Treatment.—Though powerless to accomplish much, the surgeon can do something towards retarding the fatal event. The patient must be placed on the injured side and kept perfectly quiet. Cold should be applied over the left hypochondriac region, and gallic acid freely administered, together with the wine of ergot.

The most favorable cases are those in which the organ lies in the external wound or is prolapsed. When so situated, and there is no evidence of its structure being injured, it should be carefully replaced. When, however, there exists a wound or a laceration, such a course would be improper. In the latter event, the vessels must be secured, and if the part involved be very limited in extent it should be allowed to remain in the opening. When extensively damaged, the proper course will be to encircle the mass with a stout ligature and permit it to slough away. This operation has been successfully performed in a number of instances. Dr. Hatchett,‡ after a gunshot wound of the abdomen in a soldier at Perryville, Kentucky, causing a dislocation of the spleen, surrounded the viscus with a ligature. The mass sloughed off, and the patient recovered.

The operation of removing the spleen may become necessary for other than traumatic injury. The organ is subject to hypertrophic, cystic, and other changes, and when these cannot be controlled by the usual remedies, and the disease is progressing certainly towards a fatal termination, splenotomy may be presented to the patient as a last result; but it should never be urged.

The operation, it is believed, was first performed by a Neapolitan surgeon, named Zacarelli, in 1540. It was undertaken in consequence of a mias-

* Part II. vol. ii. p. 150. † Ibid., p. 19. ‡ Ibid.

matic enlargement of the organ, and proved, it is believed, entirely successful.

There are tabulated, from various sources, 26 cases of partial and complete removal of the spleen, with the following results: it was undertaken 16 times for traumatic injury, all of which recovered; and 10 times for morbid changes, of which number 4 recovered and 6 died.*

Splenotomy.—In performing the operation, an incision should be made, beginning at the cartilaginous border of the thorax on the left side, and extending down from four to seven inches in length, external to and parallel with the linea semilunaris. The different layers of the abdominal walls are to be divided upon a director, and all vessels secured which show a disposition to bleed, before opening the peritoneum. The sides of the wound being separated, the diseased organ should be drawn out of the body and its vessels tied a short distance from the hilus. The threads are to be brought through the external wound, and the latter closed by the interrupted suture.

Wounds of the Pancreas.—Wounds of the pancreas are rare, as might be expected from its deep and sheltered position. During the War of the Rebellion two cases were reported in which there was protrusion of the organ,—a rather remarkable occurrence when we consider how firmly it is bound in position. In one of these cases the gland slipped through the external wound while the patient was in the act of straining at stool. It was removed with the wire ligature by Surgeon J. G. Thompson, death being caused, it was believed, by the implication of other organs. The second case died from hemorrhage,—a result to be expected when we consider the intimate relation of the great blood-vessels of the spleen to the gland. The existence of such wounds, aside from ocular inspection, must be purely a matter of conjecture. In none of the five cases of wounds of the pancreas reported to the Surgeon-General, three of which were under treatment for twelve days, was the true nature of the injury recognized before death. The treatment should be conducted on the same principle as that employed for injuries of the spleen.

Wounds of the Kidney and Supra-renal Capsules.—These may be incised, contused, lacerated, or gunshot. They are frequently associated with injury to the spleen, liver, intestines, or vertebræ. The fatality of wounds of the kidney depends upon the position of the injury and the portion of the organ involved. When the anterior surface is implicated, the danger is extreme, as the peritoneal sac will be exposed to urinary extravasation, which will rapidly excite a fatal inflammation. When the posterior surface of the organ alone is injured, the risk to life is lessened, that part being remote from the peritoneum and lying in a bed of loose cellulo-adipose tissue. An escape of urine into this structure may result in an abscess which will open externally.

Bruises, lacerations, or ruptures of the kidney may follow a severe blow or a fall upon the back. The rupture, in such cases, may be confined to the surface of the organ, it may involve the pelvis, or it may penetrate deeply into and even through the entire substance of the viscus, and is often accompanied by external ecchymosis over the lumbar region. The accident is usually attended with injury to other organs within the abdomen.

Wounds of the cortical or secretory portion of the kidney are represented as being less dangerous than those of the tubular or conducting portion. Urinary extravasation does not always follow gunshot wounds of the kidneys, the swelling and plastic transudation which follow the injury of the ball acting as a barrier to its escape. Incised and punctured wounds are more favorable to such escape.

The supra-renal capsules are rarely wounded. A single case is recorded during the War of the Rebellion, and one in which the ball lodged in the body and became encysted. The patient lived almost one month, and died of pyæmia, produced most probably by an extensive injury of the lung, which

* Surgical History of the War, Part II. vol. ii. p. 152.

had been inflicted by the ball and the splinters from a rib. No peculiar symptoms were revealed.

Symptoms.—The signs of a wounded kidney are not always clear. The most significant one is hæmaturia, though this is not invariably present. There is usually much uneasiness or pain in the back, with a frequent desire to urinate, the water at first being slightly stained and afterwards more deeply colored with blood. The hemorrhage into the bladder may be so great as to distend the organ with clots. There is also pain along the course of the spermatic cords, attended with retraction of the testicle. Casts and pus appear in the urine shortly after the injury, and fever and nausea are generally present at some period in the progress of the case.

The prognosis in wounds of the kidney is exceedingly unfavorable. Though twenty-six cases of alleged recoveries were recorded by the surgeons of the United States Army during the War of the Rebellion, yet Dr. Otis declines to accept many of these without expressing some doubt as to their genuineness. In these twenty-six cases the right and the left kidney suffered with almost equal frequency, the former thirteen and the latter twelve times. In one case it was not stated which organ was injured.

Assistant Surgeon R. I. Perry* reports one case of recovery after a wound of the kidney in which there could be no reasonable doubt as to the verity of the diagnosis. Numerous cases of recovery after shot wounds of the kidney are recorded by various surgical writers, both military and civil,—among them being Legouest, Baudens, Guthrie, Hennen, Dupuytren, Billroth, Stromeyer, Pendleton, and Richardson.

Hennen† gives the history of an officer who was shot, the ball being afterwards extracted at the side of the twelfth dorsal vertebra. The wounded man suffered intense agony in the back, and passed bloody urine. Seven weeks after, an abscess formed in the lumbar region, which, on being opened, discharged offensive matter and a fluid having a urinous odor. A second abscess formed lower down, from which a similar discharge took place. After this the passage of the urine became more difficult, and finally it could only be discharged in drops. While making an agonizing effort to empty the bladder, a burst of urine, accompanied with the discharge of a piece of cloth, took place, after which the patient's recovery was rapid. This foreign substance had been carried by the ball into either the substance or the pelvis of the kidney, and from thence had passed along the ureter to the bladder, from which it was discharged through the urethra. Stromeyer furnishes the case of an officer who, two months after a shot wound of the kidney, passed a concretion from the bladder. The inference was that this had formed in the pelvis of the kidney and passed into the bladder through the ureter.

The immediate causes of death after a wound of the kidney are hemorrhage, shock, and urinary infiltration giving rise to peritonitis. The causes which operate at a later period to destroy life are pyæmia, abscess, cystitis, and hectic fever. As wounds of the kidney are so generally complicated with those of other portions of the abdominal contents, it is difficult to determine what part of the mortality should be credited to the former.

Treatment.—As in other wounds, any foreign body which can be discovered, without a too officious exploration, must be removed. If urine flow from the opening, no obstacle should be offered to its escape. The patient should be placed in such position as will favor a free drainage from the wound, not only of the urine, but also of other discharges. If the signs of internal hemorrhage are present, the surgeon must insist upon entire quietude of the body; he should administer gallic acid and ergot, and, if pain is experienced, should direct a sufficient amount of opium to allay all suffering. If there is shock, it is better to allow the patient to rally by the recuperative forces of his own body, without any active interference on the part of the surgeon, as the

* Confederate States Medical and Surgical Journal; Surgical History of the War, Part II. vol. ii. p. 144.

† Military Surgery, p. 422.

danger of hemorrhage is thereby much lessened. If, however, the shock amounts to collapse, external warmth and stimulation will become imperative. As all undue activity of the kidney is to be deprecated, no fluids should be allowed further than may be necessary to relieve urgent thirst. When reaction sets in, it must be controlled by the use of refrigerants and sedatives. In the event of coagula forming in the bladder, they should be broken up and removed by the use of a large-sized catheter, through which should be injected a weak alkaline solution, with a view to dislodge the clots and prevent the further coagulation of blood. To obviate the difficulty arising from the eyes of the catheter becoming obstructed with coagula of blood, a Clover's apparatus or an aspirating bottle may be connected with the instrument, by which it can be kept clear.

Sequels of Abdominal Wounds.

Inflammation of the Kidney.—Should inflammatory symptoms of the kidney arise, they must be controlled by saline cathartics, by cupping over the loins, by the use of the hip-bath, or by warm poultices applied to the lumbar regions. Opium will be required, given to the extent necessary to relieve pain.

Perinephritic abscess.—Whenever abscesses form, they should be early evacuated by free incisions. Nourishment by the mouth had better be withheld for the first two or three days, or until there is reason to believe that the intestines have escaped injury, after which milk and animal broths may be allowed.

Fistulæ.—These may succeed abscesses. The discharge of urine and purulent matter will oppose the healing either of an abscess or of a wound; the opening will contract and granulate up to a certain point, leaving a narrow canal, which may obstinately refuse to close.

The treatment of such cases consists in cleansing the parts and waiting patiently to see if the opening does not gradually become obliterated. There are a number of instances recorded in which obliteration was eventually consummated. If, however, after a reasonable delay, the case continues unchanged, it will be proper to examine the sinus with a view to discover if there is any cause for a continuance of the fistula, which it is possible for the surgeon to remove. If the fistulous track is sinuous or circuitous, it should be incised so as to make the opening between the kidney and the surface of the body as direct as possible; if a urinary salt has incrusted the walls of the fistula, this should be removed by injections of dilute nitro-muriatic acid; and if a calculus has formed in the course of the sinus, its extraction should be immediately effected. As a last resort, it has been advised both by Simon and by Billroth to extirpate the kidney. Such an operation was done successfully by the former surgeon.

In addition to fistulæ of the kidneys and ureter, already described, there may be similar openings communicating with the stomach, liver, gall-bladder, and intestines.

Fistula of the Stomach.—This may arise from wounds, cancer, and abscesses, and, from whatever cause, usually proves fatal. The well-known case of Alexis St. Martin is an example of gastric fistula following a wound. Dr. Middeldorpff* and Dr. Murchison have collected forty-six cases of such fistulæ, twenty-one in men and twenty-three in women, with two in which the sex was not ascertained. Those having a traumatic origin were most commonly met with in men, the non-traumatic in women. Three cases of traumatic gastric fistula were recorded during the War of the Rebellion.† These were not immediately established, but followed the wound at periods varying from two to seven weeks. All proved fatal; one living one week, another four weeks, and the third almost twelve weeks. But two recoveries

* Brit. and For. Med.-Chir. Review, Oct. 1860, p. 545.
† Surgery of the War, Part II. vol. ii. p. 52.

from gastric fistula after gunshot wounds have been recorded,—one being St. Martin, who still lives with a permanent fistula; the other a French soldier, recorded by Baron Percy, who was wounded in 1794, and in whom the fistula healed spontaneously.

Treatment.—No attempt in the way of an operation should be made to close up a gastric fistula until nature has done all in her power towards that end. Should the patient survive any length of time, the wound will contract very much by cicatrization, leaving a fistulous track quite small as compared with the original opening. This may be reduced still further in size by cauterization with nitrate of silver. When closed to its smallest dimensions, the alternatives will remain, either to employ some mechanical appliance, as an obturator, or to turn into the fistula (its edges having been previously freshened) a flap of integument taken from the neighborhood of the opening, the cutaneous surface of which should be placed inwards, and retained by a few silver sutures. I am not aware that this operation has been performed; but, as it succeeds in exstrophy of the bladder and in fistulous openings of the larynx, there is no reason why it should not be attempted in gastric fistula. Middeldorpff almost succeeded in curing a case by attaching a flap of skin to the edges of the opening.* In this case, I believe, the raw surface was placed inwards. When there are fistulous tracks, other than the one connecting with the stomach,—tracks which burrow in the subcutaneous tissues,—they should be laid open and thus obliterated, preliminary to any operative measure for closing the abnormal opening. As the fluids which flow from gastric fistulæ are profuse in amount, the greatest attention must be observed to keep the parts clean. Oakum placed over the opening will form the best external application for this purpose, and should be renewed as often as it becomes soaked with the discharges.

Fistula of the Gall-Bladder.—Biliary fistulæ are not common. They occur as a result of distention of the gall-bladder by an accumulation of calculi, from obstruction of the common bile-duct caused by inspissated mucus, or from the pressure of a malignant growth. Abscess of the liver, blows over the right hypochondrium, gunshot and other wounds, are also causes of the disease. Antecedent to such fistulæ, the gall-bladder becomes adherent —through inflammation—to the abdominal walls. In this way the biliary secretion is prevented from coming in contact with the peritoneum. The discharges which flow from the fistula consist of bile, muco-pus, and sometimes blood. I once removed a number of gall-stones from the iliac fossa of a lady. They had reached this locality in all probability by adhesion of the gall-bladder to the iliac fascia, and by subsequent ulceration. These fistulæ rarely ever close, but wear the patient out by prolonged irritation.

Treatment.—The parts around the fistulous orifice are to be kept clean, and defended against the irritating discharges. If biliary calculi are found in the opening, they must be carefully extracted. Little success can be expected from any operation contemplating a closure of the fistula; and should it be the result of a permanent obstruction of the principal bile-ducts, all attempts of this kind are obviously improper.

Fæcal Fistula.—Fæcal fistula is the result both of accident and of disease. Under the first head may be enumerated contusions, blows, gunshot and other wounds of the abdomen: under the last, intestinal obstruction from various causes, such as accumulations within the bowel, stricture, cancer, etc. There is an intestinal fistula which sometimes follows strangulated hernia, commonly called *artificial anus*, but which possesses certain peculiarities, to be noticed farther on. In the first, or ordinary fæcal fistula, only a portion of the intestinal tube is destroyed, the surrounding parts becoming adherent to the abdominal walls, thus cutting off all communication with the cavity of the peritoneum (Fig. 235), and preventing a fatal ex-

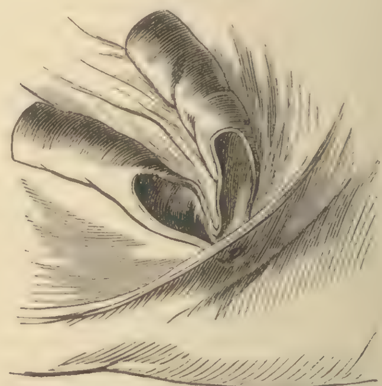
* Holmes's System of Surgery, Part II. vol. ii. p. 683.

travasation of the contents of the bowel. This work of the inflammatory adhesion of two serous surfaces—that of the intestine and that lining the abdominal parietes—precedes the formation of the external opening, while in cases resulting from wounds it follows the lesion in the abdominal walls. If there is a large part of the intestinal wall lost, the entire contents of the bowels may be discharged through the opening. Especially will this be the case if the angle formed by the two sides of the adherent loop of intestine is acute,—as such a position favors the formation of an internal ridge or septum which is projected from the mesenteric portion of the bowel (Fig. 236), as

FIG. 235.

Intestinal fistula. A loop of intestine is adherent to the abdominal parietes at an obtuse angle, the fistulous opening involving only a small extent of the tube.

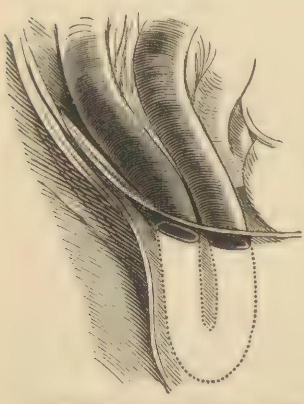
FIG. 236.



Intestinal fistula. The loop of intestine is adherent to the abdominal walls at an acute angle, thereby forming a spur or ridge.

well as a prolapse of the mucous membrane into or through the external opening in the abdominal walls. When, on the other hand, this angle is obtuse, this mechanical obstruction does not exist, and consequently only a portion of fæcal matter escapes through the fistula, the remainder passing down along the natural channel. Sometimes this slight angular disposition of the adherent gut is such that no stercoraceous matter is discharged externally, except when the contents of the bowels are very thin, as in diarrhœa.

FIG. 237.



A diagrammatic view of a loop of intestine which has been strangulated. The dotted lines represent the knuckle which has sloughed off at the seat of constriction, above which are seen the two orifices of the bowel, and the relation which the tubes hold to each other.

In the artificial anus following strangulated hernia a different condition exists from that described above. In hernia, a loop or knuckle of the intestine is protruded through the hernial passages, so that when its vitality is destroyed by the stricture and all below sloughs off, there remain two intestinal tubes lying alongside of each other, like the two barrels of a double-barreled gun, the canals of which are discontinuous, and their two orifices look outward towards the external opening. (Fig. 237.) It is possible, however, after hernia to have a stercoraceous fistula similar to that first described, as when an intestine, after division of the stricture, is returned into the abdomen under the impression that its structure has not been seriously injured, and yet afterwards a portion of the tube sloughs, and the opening left becomes attached to the upper part of the canal. This attachment may occur without

an internal extravasation of fæces, most probably because the incarceration destroys the peristalsis, and while in this quiescent state the tube becomes glued fast to the walls against which it lies, by inflammatory action. In the two varieties described, namely, fæcal fistula and artificial anus, the openings into the intestines are immediately in contact with the walls of the abdomen. Holmes speaks of two other varieties, one in which the orifice into the gut is attached to the upper part of the hernial sac which had been previously restored into the body, and which necessarily removes this opening some distance from the parietes; and another in which the opening of the gut discharges into a canal formed in the plastic deposit which agglutinates the contiguous coils of intestine, and through which the fæces flow to the external orifice in the abdominal walls. This last I have never seen, and think it must be a rare form of the disease, for, so far as my observation extends, it is not common to find other loops than the affected one glued together by inflammatory transudation. It is not uncommon to have several external openings in fæcal fistulæ, the result of dissecting abscesses in the parietes, a condition which materially complicates the cure.

Prognosis.—Fæcal fistulæ involving the small intestines are unfavorable in their termination. This part of the alimentary tube being chiefly concerned in the work of nutrition, its contents are in a liquid state, and their escape is followed by emaciation and loss of strength, the patient finally dying from inanition. When the angle of this bowel is very acute at the point of union with the parietes, and as a consequence the spur or septum much prolonged from the mesenteric border of the intestine, so as to prevent the contents passing down into the bowel below, the prospects of a favorable issue are materially lessened. In fæcal fistulæ of the large intestine the prognosis is much more favorable. The solid state of the contents of the colon, and their effete nature, are conditions which conduce to recovery; and when the more fixed portions of this intestine are implicated, as the cæcum, the ascending or the descending portion, the probabilities of a cure are greatly enhanced. Of fifty-nine cases of such fistulæ in the Reports to the Surgeon-General of the United States Army,* fifty closed, nine remaining open. The time required for the healing of forty-six of this number was, in seventeen cases, one month; in twenty-eight cases, one year; and in five, periods varying from one to four years.

Treatment.—In ordinary stercoraceous fistula, the wisest course is to leave the case to purely natural processes. Should there, however, be a number of sinuses or fistulous tracks in the walls of the abdomen, it will be necessary to lay them all freely open upon a director, except the one most directly connected with the opening in the intestine. The parts must be kept clean, and the person of the patient rendered free from odor by frequently renewing the dressings. The best compress in such cases is a pledget of oakum (previously treated with a solution of the sulphate of iron), which should be laid over the fistula and kept in place by a broad binder, or by adhesive plasters. After cicatrization has materially diminished the opening, a firm compress of oiled linen, containing a piece of heavy sheet-lead, should be placed upon the aperture, and over this the oakum, the whole dressing being secured by a bandage. This plan of pressure, which is that of Desault, will often effect a cure, and should be thoroughly tried before having resort to an operation. It fulfills very much the same indication as the recumbent position recommended by Brodie,—both tending to direct the intestinal contents towards the posterior surface of the bowel. Often the slightest external opposition to the escape of the feculent matter will suffice to turn its course into the bowel below. The plan has in several instances proved successful in fæcal fistulæ which have come under my care. Many curious devices intended as obturators have been invented with a view to plug up the outer orifice; but these appliances, tending as they do to prevent contraction of the fistula, exercise a pernicious influence, and should be rejected. The

* Surgical History of the War, Part II. vol. ii. page 98.

best mechanical contrivance I believe to be a hard rubber truss, which should possess a large pad, and be placed over the fistulous opening, with a pledget of soft oakum interposed between the surface and the pad. The pressure from this instrument affects only the surface, and, while it prevents prolapse of the mucous membrane of the bowel, it also restrains, to a considerable degree, the escape of fæcal matter. Should the above measures fail, the use of the actual cautery, applied to the edges of the fistula, from time to time, will in some instances effect a closure of the opening by cicatricial contraction. In my own hands all attempts to cure these fistulæ by operation have signally failed.

Artificial Anus.—In fæcal fistula, known as artificial anus—usually a consequence of strangulated hernia—the condition of the person is most pitiable, being so offensive to himself and his friends that it is entirely proper to resort to operative measures, even though at considerable risk to life, in the hope of being able to rescue the patient from a most deplorable infirmity.

Fig. 238.

Thread introduced through the intestinal septum, and the ends hanging out of the wound.

The obstacle to be overcome in this form of artificial anus is the septum formed by the walls of the two intestinal tubes, which lie in contact with each other, and which, like the spur or ridge resulting from the angularity of the bowel in other forms of fæcal fistulæ, constitutes the chief difficulty in the way of a cure.

All of the operations devised for this object have been inspired by the suggestion, in 1798, of Schmalkalden, a German surgeon, and consist in dividing this septum or partition by a thread introduced through its substance by means of a curved needle, bringing the ends out of the external opening, and gradually tightening them, in order to establish by ulceration a permanent opening through the obstruction. The first surgeon to carry this suggestion into effect was Dr. Physick, who, in 1809, operated with success upon a patient in the Pennsylvania Hospital. His method differed somewhat from that advised by Schmalkalden, in that the

Fig. 239.

Dupuytren's enterotome.

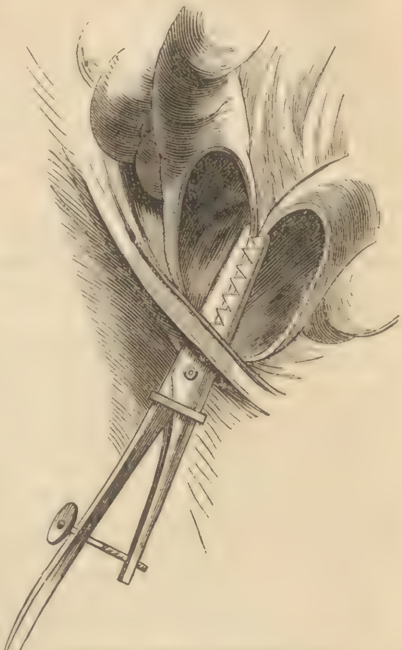
ligature was used for seven days, only with a view to insure consolidation or union between the contiguous walls of the intestine (Fig. 238), the opening being afterwards made by a curved bistoury, after the removal of the thread.

Dupuytren employed an enterotome (Fig. 239), a form of forceps with serrated blades, and having a screw in the handles by which the instrument could be tightly closed. In using this instrument, the blades are conducted one into each intestinal orifice, guided by the previous introduction of a catheter, and, after the position of the partition has been ascertained, the handles are screwed together (Fig. 240) with sufficient force to induce colicky pain. After the lapse of seven or eight days the instrument becomes loose and may be removed. The part compressed is destroyed, and will soon separate as a

slough, establishing the desired opening between the two contiguous tubes. The value of this operation may be judged from the fact that it has been successful in closing more than forty cases of artificial anus.

To correct a defect in the enterotome of Dupuytren, that of making unequal pressure, in consequence of which the septum is divided first nearest to the articulation of the blades, Blasius introduced an instrument the blades of which are parallel and are moved by a screw. Dr. Lotz, of Pennsylvania, invented an instrument in which this parallelism of the blades is conjoined with fenestræ. (Fig. 241.) These fenestræ are about one-quarter of an inch wide and one inch long.

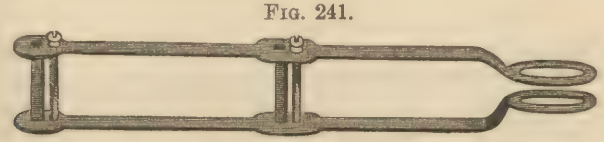
FIG. 240.



Application of Dupuytren's enterotome.

The instrument of Professor Gross, designed for the same purpose (Fig. 242), is a forceps with fenestræ like those of Lotz's. In the use of these fenestrated appliances the blades are introduced, one into each orifice of the bowel, and then brought together and secured either by screws, as in Lotz's, or by a button catch, as in Professor Gross's instrument. As soon as adhesion has taken place between the walls of the intestine, a result usually requiring three or four days, the septum should be divided by a curved bistoury passed through the fenestræ, after which the instrument is to be gradually relaxed, and in two or three days more entirely removed. During the time the enterotome remains in the bowel it will be necessary to alleviate the suffering of the patient with opium or morphia. If successful in opening the normal route for the fæces, it will be essential next to address remedies to the external opening, with a view to insure its cicatrization. For this object we may employ nitrate of silver or sulphate of copper, conjoined with external compression.

FIG. 241.



The instrument of Dr. Lotz.

FIG. 242.

Professor Gross's forceps for the cure of artificial anus.

Should all other measures fail, and if there is no anatomical objection, the surgeon may call to his aid the resources of anaplasty; though the success which has heretofore followed these attempts has been by no means encouraging.

Wounds of the Pelvis.

Wounds of the pelvis may be classified according as they involve the external soft parts, the bones, the contents, or all three together.

These wounds may be contused, incised, lacerated, punctured, and gunshot, and often prove to be very serious accidents.

Wounds of the Soft Parts.—Contusions, the result generally of forcible pressure, as when a person is caught between the buffers of cars, are followed often by large blood-swellings, especially when the violence has been received upon the nates. This collection of blood may be subcutaneous or in the midst of the gluteal muscles, and usually does not descend lower than the gluteo-femoral groove, in consequence of the anatomical arrangements of the fascial and muscular structures isolating in a good degree the nates from the thigh. When the contusion is less severe, such as follows a kick, there is a liability to the formation of abscess, greater, I think, than when similar violence is applied to other regions of the body. As the gluteal muscles are actively concerned in walking, standing, and indeed in almost all of the movements of the pelvis upon the thighs, these contusions produce no small degree of disability or lameness.

Treatment.—Rest and anodyne lotions, such as lead-water and laudanum, constitute the chief remedies. The blood-swellings commonly disappear in time, and on no account should these be opened, except when they provoke suppuration. Should an abscess form, whether from the irritation of blood or from an inflammatory disturbance, the matter must be evacuated early, as it tends in this region to become disseminated and to cause much damage to the parts. Incised and lacerated wounds should be closed by the interrupted silver suture and supported with a well-fitting compress, secured by the gluteal sling or the gluteo-femoral handkerchief. Gunshot wounds of the soft parts are often very slow in healing,—whether the missile remains in or passes out, —particularly when the track of the ball is extensive and sinuous.

Fistulous openings frequently remain, in consequence of the movements of the muscles, and give rise to the suspicion of bone-disease when nothing of the kind is present. If a ball lodges in the soft parts, a proper search for its location must be made, and, when found, it should be promptly extracted.

Rest and pressure are nowhere so important as in these wounds, and, should abscesses form in the buttocks from tortuous ball-tracks, our chief reliance will consist in laying them open, or in dilating them and introducing a drainage-tube, in order to avoid the formation of pockets for the accumulation of pus.

Wounds of the Pelvic Bones.—In shot wounds or fractures of the pelvic bones, the ball may make a clean perforation, may graze their surfaces without penetration, or may produce extensive comminution. The ilium, from its extent and position, is more exposed, and consequently suffers oftener, than the other pieces of the pelvis. This will appear with greater force when we learn that out of 1494 cases of gunshot fractures of the pelvic bone, during the War of the Rebellion, the ilium suffered in 829 instances, and in 799 of these it was the only bone involved.* The left ilium, it was also noted, suffered oftener than the right.

The prognosis after gunshot fractures of the ilium is favorable when the injury is confined to the bone and does not involve the contents of the pelvis. In the 799 shot injuries just referred to, the result was ascertained in all but 13 cases, giving a mortality of 192.

Gunshot fractures of the pubic bones are more serious than those of the ilium. The relation of the bladder and the close proximity of the femoral, obturator, and spermatic vessels will explain this fact. The records of the late American war supply 86 cases of such injury, with 43 deaths. The

* Surgical History of the War, Part II. vol. ii. p. 213.

largest number of the fatal cases—one-third—died from complications of the bladder. Dr. Otis observes that this bone, owing to its toughness and its fibrous and tendinous attachments, is rarely comminuted.

Shot fractures of the ischium, from the dependent position of the bones, are less dangerous than those of the ilium. We learn from the "Surgical History of the War" that there were 73 such injuries returned, with a mortality of 35.

The sacrum supports the rectum and the large plexus of nerves which endows the extremities and the pelvic viscera with motion and sensation. From this fact it would be supposed that, when the sacrum is shattered by gunshot missiles, the injury must be attended with the most serious consequences; but the statistics do not sustain this conclusion. Of 142 such fractures, 62 died. In an aggregate of 1545 pelvic fractures, there were 570 deaths. This cannot be regarded as a heavy mortality, when it is considered that in most cases some portion of the contents participated in the injury, though occasionally a ball was known to have traversed the pelvis without doing any damage to its viscera.

In many instances of shot wounds of this part, the resulting evil is due to splinters being detached from the bones and driven into the bladder, rectum, and other parts within the cavity of the pelvis, so that while it is necessary in a systematic treatment of gunshot wounds of the pelvis to make the distinction between those affecting its bony walls and those implicating its contents, it is nevertheless true that the two are not often dissociated.

Treatment.—In shot fractures of the pelvic bones it is important to ascertain if any osseous fragments or splinters, portions of clothing, or other foreign matters have been driven into the interior. The finger should diligently explore the track made by the missile, and, if necessary, the external wound may be enlarged for that purpose. A finger in the rectum may aid in discovering displaced fragments of bone. Should any such be detected, their removal will conduce immensely to the patient's recovery.

A second indication is to maintain a free escape externally of all inflammatory products, which is best effected by conducting to the bottom of the wound a good-sized drainage-tube. The probability of the bladder being injured requires that a soft catheter be immediately introduced into the organ and retained for three or four days, to guard against urinary extravasation.

The position of the patient also demands some attention, with a view to prevent displacement of fractures by muscular action. If the crest of the ilium has been broken, the body should be inclined towards the affected side, so as to relax the broad muscles of the abdomen which are attached to its surface. If the anterior superior spinous process has been detached, the thigh will require to be flexed, in order to relax the sartorius and the tensor vaginæ femoris. Great comfort is derived from surrounding the pelvis with a broad bandage, so as to remove the distressing feeling so commonly complained of, *i.e.*, that of "falling apart." Should abscesses form in the soft parts overlying the pelvic bones, they must be opened as soon as recognized, in order to prevent burrowing between the planes of the gluteal and other muscles. If the general constitution becomes disturbed, either from the local irritation or from profuse and continued suppuration, anodynes will be required to secure relief from pain, and tonics, together with a liberal diet, to maintain the strength.

Wounds of the Bladder.—The urine being an exceedingly irritating secretion, any injury which destroys the continuity of the coats of the bladder, permitting an escape of its contents, usually proves quickly fatal.

Rupture of the bladder.—This accident has occurred many times, and may be produced by the wheel of a loaded wagon passing over the lower part of the abdomen, by a kick given in a drunken brawl, or by a fall against some projecting object. The accident cannot readily occur except when the viscus is considerably distended by urine. In the collapsed or empty state, it is sheltered by the pubic bones, and, remaining within the pelvis, is out of the

way of violence applied over the hypogastric region. The accident occurs most commonly in persons who are under the influence of liquor. It is well known that individuals in this state, having their sensations blunted by the stupefying influence of alcohol, neglect to empty the organ, except when it is much distended. In addition, the muscular system of a drunken man is in a relaxed, helpless condition, and in a great measure powerless to resist force, so that when a blow is applied over the lower part of the abdomen, it reaches the bladder without opposition, and determines the rupture. Besides the causes already enumerated, the organ may be ruptured from over-distention, caused by some mechanical obstruction to the passage of the urine, as in stricture of the urethra. Such an occurrence, however, is rare, and perhaps never takes place until some degeneration in the coats of the viscus is produced by long distention.

The bladder has been ruptured by the gravid uterus pressing against its walls during the throes of parturition, where the physician has neglected to use the catheter. It would appear that when a rupture takes place, the posterior wall of the bladder suffers most. In 58 cases collected by Dr. Stephen Smith, the lesion occurred 50 times in the posterior wall, 9 times in the anterior, and 6 times at the neck of the organ. In the 37 cases collected by Houël,* this unequal distribution of the lesion is not so marked, 15 being in the posterior wall, 12 in the anterior wall, and the rest, with two exceptions in which the locality was not noted, on the sides and near the urachus. Males suffered much oftener than females, due, no doubt, to differences in occupation.

The relation of the bladder to the peritoneum influences somewhat the result of these ruptures. The posterior and lateral surfaces are covered by this serous membrane, but the anterior and the "*bas-fond*" are not. When, therefore, the rent involves the posterior part, the peritoneal layer is likewise torn, and the urine reaches the peritoneal sac, kindling at once a fatal inflammation. When the anterior surface and that behind the prostate body is ruptured, the extravasation is into the cellular tissue of the pelvis, developing pelvic cellulitis and sloughing, as fatal, but not so rapid, as peritonitis. Of the 78 cases collected by Dr. Stephen Smith, only 5 recovered, the majority dying within five or six days; and of the 37 cases recorded by Houël, all but 2 proved fatal.

The bladder is not unfrequently wounded by spiculæ detached from the bones of the pelvis in fractures and by balls. Pieces of clothing, balls, hair, and other foreign bodies may pass immediately into the cavity of the bladder, or they may reach the interior of the viscus by ulceration at various periods of time after the reception of the injury.

Gunshot wounds of the bladder are less mortal than other injuries of this viscus. This fact, which was pointed out by Larrey, has been verified by the experience of the late American war. In 183 cases of this nature,† 87 survived the immediate effects of their wound, though the larger number suffered from urinary, stercoraceous, and recto-vesical fistulæ, with other sequels, which wore the patients out, in some instances after months and years of irritation. That extravasation of urine does not in all cases follow shot wounds of the bladder may possibly be due to the circumstance, as is popularly believed, that soldiers go into action with empty bladders, but more probably is to be accounted for by the reason given by Larrey, that the passage of the ball leaves an eschar which closes the opening. Be this as it may, there can be little doubt that the prospects of recovery after a shot wound of the bladder will be enhanced when the wound is far removed from its base and the organ undistended with urine at the time of the injury.

Balls and other substances, after entering the bladder, form nuclei for urinary concretions. One case of this kind came under my observation a few years ago. This patient was relieved of his calculus by Dr. Forwood, of Chester, who operated with equal success on a second case of a similar nature.

* Des Plaies et des Ruptures de la Vessie.

† Surgical History of the War of the Rebellion, Part II. vol. ii. p. 264.

The records of Otis and those of Dixon* exhibit 32 operations for the removal of calculi formed about projectiles which had entered the bladder, 13 of which number were done by American surgeons. Foreign matters, such as cloth or bone, which had entered the bladder, have been passed through the urethra. Several instances of this kind occurred during the War of the Rebellion.

Incised and lacerated wounds of the bladder are not common accidents. Punctured wounds are more frequently encountered, being produced by splinters broken off from the pelvic bones, and sometimes by the point of a bougie in cases of difficult catheterization, the anterior wall near the neck usually being the seat of the wound.

Symptoms.—When the lesion is one of rupture of the bladder, its recognition must be a matter of inference rather than of absolute certainty. After a blow or fall upon the abdomen, if there follow diffused pelvic pain, great anxiety of countenance, collapse, vesical tenesmus, and hæmaturia, there is just ground for suspecting the existence of rupture. If, in addition to these symptoms, a catheter introduced into the bladder draws nothing but a little blood, and if the statements of the patient furnish reasonable evidence that no urine had been passed for some hours before the injury, the existence of rupture may be regarded as almost certain.

In estimating the value of catheterism as a means of diagnosis, it must not be overlooked that it is possible to draw a large quantity of urine even after a rupture of the bladder; but in such cases the instrument passes through the rent and enters the peritoneal sac, from which the extravasated fluid is drawn.

When there is an external wound, or when there is the additional complication of a wound of the rectum, and the urine escapes through one or both of these channels, the symptom of bladder-lesion is conclusive. The duration of life after rupture of the bladder rarely extends beyond four or five days, and when thus prolonged it is an evidence that the rent is through the non-peritoneal portion of the viscus. When the injury involves the parts covered by the serous membrane, the intense peritonitis which quickly follows will destroy life in from twenty-four to forty-eight hours. In some instances of this injury the patient has died in a few hours, never coming out of the state of collapse.

The pathological appearances which are found after wounds of the bladder differ according as the extravasation is fascial or peritoneal. When the former, the pelvic connective tissue is found necrosed and interpenetrated by urine, serum, blood, and pus. When the extravasation is peritoneal, the cavity of the abdomen contains a large amount of dirty serum, in which are suspended numberless flakes of lymph, the latter also adhering, like an incrustation, both to the reflected and to the visceral layers of the serous membrane. Though in some cases there will be found a feeble agglutination of the intestinal loops, yet, generally, only a few adhesions exist, the inflammatory transudation not being capable of organization.

Treatment.—The two great indications in the treatment of wounds of the bladder are to maintain a collapsed state of the organ and to combat peritonitis and cellulitis. To fulfill the first, a soft catheter of good size, having an opening at the extremity, should be introduced barely through the prostatic portion of the urethra. Carried farther than this, it might slip through the rent in the walls of the bladder. Here the instrument should be retained, changing it for a new one every forty-eight hours. The advantages of this course consist in removing the urine as rapidly as it enters the bladder, thereby preventing further extravasation, and, by keeping the organ empty, producing such a corrugated state of its mucous membrane as will serve to obstruct the wound in its walls. Should the case survive the first shock of the injury and escape peritonitis, thus rendering it probable that the extravasation is confined to the pelvic fasciæ, a free incision should be made through the perineum and the neck of the bladder, as in the lateral operation

* Dixon, Medico-Chirurg. Trans., 1850, vol. xxxiii. p. 19.

for stone. By such a procedure the urine will not only be safely drained away, but the extravasated and inflammatory products of the pelvic cellular tissue will be evacuated.

To combat the peritonitis, leeches should be applied over the abdomen and the patient placed immediately upon opium. The anodyne must be given in doses sufficient to control pain and quiet restlessness. After the local abstraction of blood, a light flaxseed-meal poultice, laid over the abdomen and covered with oiled silk, will contribute much to the comfort of the patient. The diet should consist of milk, and thirst, when present, may be relieved with pieces of ice.

Wounds of the Pelvic Portion of the Ureter.—Such injuries are quite rare. Hennen* mentions the case of a French dragoon, who received a musket-ball under the twelfth rib of the left side, the missile passing out to the left of the second vertebra on the opposite side. Air, which was supposed to have entered the ureter by the wound, was passed through the urethra. The case, as recorded, is open to criticism, and, as the patient recovered, the diagnosis could not be verified. Mr. Stanley † has recorded two cases, and Mr. Poland ‡ one. In those of Mr. Stanley, large urinous cysts formed in the lumbar region, which were tapped several times. One of the patients at length recovered.

The ureter has been wounded in the removal of abdominal tumors. A case of this kind was related to me by a medical friend, in which the duct was accidentally divided in extirpating an adherent ovarian cyst. The renal extremity of the tube was secured in the external wound, and a urinary fistula formed. The patient lived several months, but finally died from some obstruction in the course of the duct.

Symptoms.—Unless in cases of ovarian operation, when the parts are exposed to view, the existence of a wound of the ureter must be purely a matter of inference. Placed as the ducts are behind the peritoneum, the urinary extravasation which follows the accident may take place into the loose connective tissue below the kidney without immediately exciting peritonitis, and, as in wounds which affect the posterior part of that organ, without involving the membrane in front. An abscess or cyst may follow, which will probably point externally over the lumbar region, the tapping of which will reveal the true nature, if not the source, of the collection.

Treatment.—Should this accident result from a shot wound and be followed by lumbar swelling, an early opening will be demanded. This opening will remain as a urinary fistula, which, following the course of similar injuries of the kidneys, leaves the patient exposed to the risk of peritonitis or wears him out from constitutional irritation. With such a gloomy prospect the very grave operation of removing the kidney would be entirely justifiable.

During operations upon ovarian or other tumors within the abdomen, should the ureter be accidentally torn or divided, the renal extremity of the tube should be tied to prevent the escape of urine, and after the completion of the operation the end must be brought into the external wound and there fixed, in order to establish a fistulous opening. It was after such an injury to the duct that Simon, of Heidelberg, successfully extirpated the kidney to get rid of a urinary fistula.

Wounds of the Prostate Body.—Wounds of the prostate, other than those produced by the maladroit use of the catheter or the bougie and those designedly made in the operation for stone or in perineal section, are exceedingly rare. Not more than seven cases of shot wounds of the gland were observed during the late American war, all of which, with a single exception, proved fatal, not from the lesion in the prostate body, but from concomitant damage to the organs or to the vessels within the pelvic cavity.

* Military Surgery, p. 430.
† Medico-Chirurg. Transactions, vol. xxvii.
‡ Guy's Hospital Reports, 1869.

Symptoms.—In one of the cases of shot injury, priapism was mentioned as a prominent symptom. The discharge of blood through the urethra and of urine by the wound, and the existence of pain in micturition and defecation, possess little diagnostic value, as these symptoms may be present in other pelvic injuries, as, for example, in wounds of the bladder and the rectum. A digital exploration through the rectum, a catheter being at the same time placed in the bladder, will enable the surgeon to determine the presence of a foreign body, if such has lodged in the gland, and also to detect lacerations or loss of its substance.

In view of the attendant complications, no specific instructions can be given as to treatment. Should there be retention of the urine, the catheter will be required to empty the bladder. If abscesses form in the loose connective tissue of the perineum, the latter must be laid open and the pus evacuated. Should urinary infiltration follow, a staff must be introduced into the bladder and the viscus laid open by a free incision through the prostate, as in the lateral operation for stone, the wound being allowed to close by granulation.

Wounds of the Anus and Rectum.

Wounds of the anus and rectum may be incised, punctured, lacerated, and gunshot.

Incised wounds are not common, and when met with they are generally accidental, as when produced by the knife in dividing the neck of the bladder in lithotomy, or designed, as in the operation for fistula in ano.

Punctured wounds result from falls upon the handles of hay-forks or upon the rounded or pointed posts of chairs and iron rods, and from the too forcible use of the rectal bougie in cases of stricture.

Hall* records a singular case of punctured wound of the rectum in a man who fell some distance upon the stem of a tree the size of a walking-stick. It entered the anus, passing up the bowel a distance of ten inches, or until arrested by his feet striking the ground. Not only was the rectum torn, but the bladder also was opened, the urine escaping for days from the anus. The patient, notwithstanding the formidable nature of the wound, entirely recovered. A similar accident is recorded in the London Medical Gazette,† in which a chair-leg entered the anus, penetrated the anterior wall of the rectum, passed into the bladder as high as its apex, and wounded the peritoneum. The injury proved fatal in twenty-four hours.

Dr. Forwood,‡ of Maryland, met with a case of rectal injury produced by the sharpened foot of a chair entering the ischio-rectal fossa and penetrating the bowel above the upper sphincter; and Dr. Compton,§ of Indiana, reports a wound of this nature made by a man sitting down upon the sharp extremity of a corn-stalk. The careless use of the clyster-pipe has been known to produce a wound of the rectum. Mayo relates such a case, in which, after the perforation, the injection was thrown into the abdomen, destroying the patient by peritonitis. Professor Pope gives the history of a child who was fatally injured in this way; and a professional friend has quite recently communicated to me the details of a serious pelvic cellulitis induced by the bungling use of the injection-pipe.

The rectum may also be detached from its surrounding connections without its walls being opened. A young woman was brought into the University Hospital with such an injury, the bowel having been torn from the sacrum by a car-bolt in a railroad accident, from the effects of which she died. Lacerations of the anus and rectum are caused by the horns of enraged animals, and quite frequently by the fœtal head when too long in contact with an over-distended perineum. In such instances the perineum is first torn, the rent afterwards extending into the bowel.

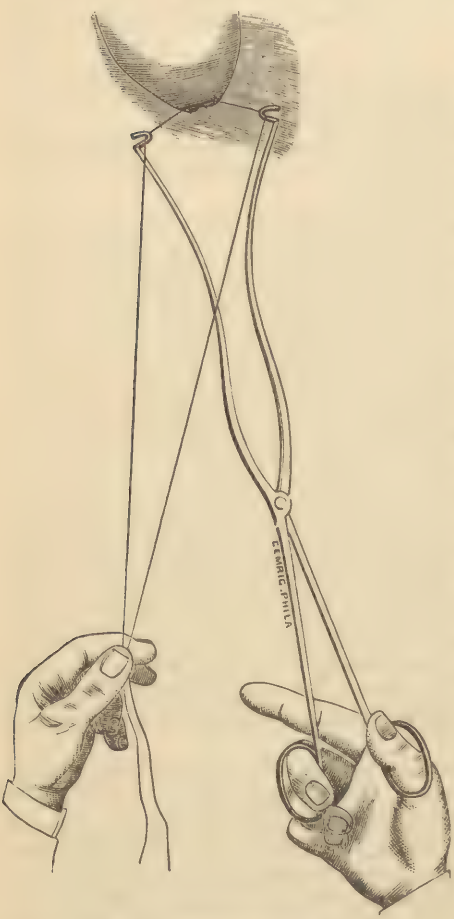
Symptoms.—These wounds are followed by profuse bleeding, from the injury

* American Journal of the Medical Sciences.
† February, 1847.
‡ Medical and Surgical Reporter, Sept. 1876.
§ Ibid., Nov. 18, 1876.

sustained by the hemorrhoidal vessels. The hemorrhage from the veins is often more profuse than that from the arteries. A simple inspection of the parts with the eye, especially when the anus is involved, will be sufficient to detect the injury. When higher up in the bowel, a finger introduced into its cavity will serve to discover any opening which may exist, and if an external wound is present, a probe passed through it may be made to touch the finger in the bowel, should there be a communication between the two. The escape of air or of fæces through the wound in the contiguous parts will serve to reveal its true nature. When there is no external opening, the use of the anal speculum will afford valuable assistance in determining the presence of an internal one. It is in cases where an internal opening alone is present that the escape of the contents of the rectum into the surrounding parts produces inflammation and suppuration in the connective tissue of the perineum.

Prognosis.—When the wound is a lacerated one, and there is much disturbance of the surrounding connections of the rectum, there is always ground for anxiety. Hemorrhage, diffuse cellulitis, abscesses, sloughing, pyæmia, and peritonitis are the probable consequences of such an injury.

Fig. 243.



Carroll's knot-tying instrument.

Treatment.—Wounds of the anus demand little attention; they heal up kindly in a short time, only requiring cleanliness and the use of water-dressings. When the rectum is involved, the great object is to prevent fæcal and gaseous extravasation, and to insure the absolute quietude of the parts for a few days. To accomplish these indications, the rectum should be cleared of all fæcal matter by repeated injections of tepid water, after which opium must be given in doses sufficient to guard against the descent of the contents of the intestine into the rectum, for a period of eight or ten days, by which time we may hope that the wound in the bowel will be closed. To prevent fæcal extravasation, if the rectum cannot be kept empty, the sphincters should be divided, so as to allow a free escape from the gut.

The diet should consist chiefly of cold scalded milk, so as to have as little effete matter as possible remaining in the bowels. After the lapse of twelve days a very gentle laxative may be administered, such as a compound rhubarb pill, or the compound liquorice powder, either of which will give a solid stool.

Should the wound fail to heal by this plan of treatment, there remains but one course, namely, that of laying the parts open from the perforation to the surface, as in anal fistula, and then allowing the chasm to fill up by granulation; or, if the wound is too deep for the safe use of the knife, by introducing the elastic ligature and dividing the parts by the slower process of ulceration.

Gunshot Wounds of the Rectum.—Such wounds were by no means uncommon during the late war, and frequently proved fatal from hemorrhage, pelvic extravasation of fæces, and exhausting suppuration. The hemorrhage may come from the hemorrhoidal, gluteal, or iliac vessels. Shot wounds of the rectum are frequently complicated with similar injuries of the bladder, also with fæcal or anal fistulæ, paralysis of one or both of the lower extremities, with injury to the sacral nerves, and with fracture of the bones of the pelvis.

Treatment.—The great indications in gunshot wounds of the rectum are to arrest hemorrhage and to prevent fæcal extravasation. The control of bleeding—when from the bowel—is best effected by dilating the gut with a speculum, and searching for the point whence the blood issues. When found, the vessel, with some of the surrounding tissue, should be lifted by a tenaculum, and a thread passed over the instrument with a pair of forceps. To tie the ligature—with the finger—in such a location is no easy task. It is best accomplished with Carroll's instrument (Fig. 243), or the vessel may be seized with a pair of spring forceps, the blades locked, and the instrument allowed to remain. When the hemorrhage comes from several points, or from an extensive surface of the intestine, a fenestrated wire speculum should be introduced, by which the bowel can be well dilated. The free admission of air, and the stretching to which the parts are subjected, will produce a hæmostatic effect, or, if this is not sufficient to arrest the flow, a stream of ice-water, alum-water, or dilute Monsel's solution of iron, may be thrown continuously from a syringe into the cavity of the gut. The instrument of Dr. Bushe (Fig. 244), consisting of a bladder fitted to a nozzle with a stop-cock, is used for the same purpose. The bladder is passed into the rectum, and afterwards filled with ice-water. Thus distended, it not only communicates cold to the parts, but also acts as a compress. At the same time the hips of the patient should be elevated, in order to relieve the hemorrhoidal vessels from the blood-pressure.

Fig. 244.

Bushe's compressor for hemorrhage from the rectum.

To prevent fæcal extravasation, the sphincters may be divided, as practiced by Dupuytren, Simon, and several American army surgeons. Though not always successful in obviating such extravasation, the operation undoubtedly promises better results than can be obtained from any other measure at our command.

Wounds of the Diaphragm.—It is somewhat difficult to determine the exact import of wounds of the diaphragm, as they are rarely uncomplicated, the attendant injury sustained by the thoracic and abdominal viscera being quite sufficient, independent of any diaphragmatic lesion, to cause death. They are, however, not invariably fatal. The constant movement to which this muscle is subjected in carrying on the work of respiration prevents, generally, the restoration or healing of perforations made through its structure. This fact, first stated by Guthrie, was amply confirmed by the observations made during the War of the Rebellion, in which 126 cases occurred. On this account it is quite common for portions of the abdominal viscera, which from their connections admit of much movement, to pass through these abnormal openings into the chest, constituting diaphragmatic hernia. In a case recorded by Dr. Sargeant, a portion of the colon was attached to the second rib. Death has followed from strangulation of the intestine in the opening.

The diaphragm is sometimes torn or ruptured by violence applied to the external walls of the thorax, such as forcible compression, or falls,—an effect which is no doubt due to the extraordinary effort made by the muscle to resist the squeezing of the border of the chest. In this view, the rupture is more the result of muscular power than of the outward injury. The left side of the muscle is much more frequently ruptured than the right, a fact

which is explained by the preponderance of the muscular over the tendinous structure on that side.

There are no symptoms characteristic of wound or rupture of the diaphragm. If, after an injury to the body, there should be gurgling sounds and a tympanic resonance heard in the chest, indicating the presence in the thorax of some portion of the viscera of the abdomen, such an accident would be rendered probable. No special treatment, other than rest and the alleviation of any pain experienced, will be required.

CHAPTER V.

WOUNDS OF THE EXTREMITIES.

The danger of wounds of the extremities consists in the injury done to the blood-vessels, nerves, articulations, and bones.

The principal blood-vessels, whether the limb be in a state of repose or of defense, are so situated as to be least exposed to harm. When the arm hangs quietly by the side of the body, the brachial, radial, and ulnar arteries are directed inwards, and the palm of the hand, in which lie the palmar arches, is turned backwards. When the arm is raised in an attitude of offense or of self-defense, the same vessels remain in the least exposed position. In the lower extremity, the femoral artery passes to the inner and posterior part of the thigh, the posterior tibial is placed between two planes of muscles, and the anterior tibial is likewise deeply situated, besides receiving an additional protection from the salient spine of the tibia. At the inner ankle, where the posterior tibial passes into the foot, a deep recess exists, formed by the concavity of the os calcis and the projection of the internal malleolus, which conduces greatly to the safety of the vessel.

Wounds of the Upper Extremity.

When a wound involves the integument, or both the integument and the muscles, the treatment does not differ from that proper to similar injuries in other parts of the body. The hemorrhage must be controlled, all foreign substances removed, the parts united by the interrupted silver suture, a pledget wet with water applied over the wound, and the dressing confined in position by a roller bandage. When a muscle is divided, the stitches should include its extremities, and the arm be placed in that position which will insure the most perfect relaxation of the parts. Tendons, when severed, should be united by the animal suture.

The most vital portions of the upper extremity are the following: *First.* The axilla, especially that part below the middle of the clavicle, in which lie, not far from the surface, the axillary artery and vein, the cephalic vein, and the axillary plexus of nerves: below this point the great folds of the armpit, and the relation of the latter to the side of the chest, serve to shelter the axillary vessels and nerves from injury. *Second.* The inner edge of the biceps, along which lie the brachial artery and median nerve, is another vulnerable region. *Third.* The antibrachial fossa, or that part in front of the elbow, is an important space. In this are situated the median basilic and the median cephalic veins, together with numerous filaments of the internal cutaneous nerve, and deeper, under the bicipital aponeurosis, the brachial, radial, ulnar, and interosseous arteries, with the median nerve. *Fourth.* In the forearm over the course of the radial and ulnar arteries, the former of which is superficial in its entire extent, the latter also at its lower fourth, in which situations these vessels are particularly exposed to injury. *Fifth.* At the root of the thumb, where the radial artery passes to the back of the hand, and in the palm of the hand, in which are lodged the two palmar arches with their numerous large, inosculating branches. In this last portion of the upper extremity we have a region which, when wounded, demands for its treatment the highest surgical skill.

Wounds of the Arm.—The arteries of the arm are frequently divided by stabs or cuts; they are sometimes torn in fractures, or, in the case of the axillary, by forcible attempts to reduce old luxations. Not unfrequently the vessels at the wrist or in the hand are wounded by chisels or by broken pieces of glass. When the axillary or the brachial artery has been severed, there will be no pulse felt at the wrist. If the damage to one of the large vessels of the arm is caused by a bullet or by a puncture, there follows a swelling more or less diffused, in which pulsation is generally detected.

Treatment.—In all injuries of the blood-vessels of the arm and the forearm, the proper course is to seek for the artery in the opening made by the vulnerating body, enlarging the wound, if necessary, for the purpose, and tying both ends of the divided trunk. When a ligature is placed on the proximal end of a wounded vessel, above a collateral branch, the latter should likewise be tied: otherwise the blood may find its way back through the anastomosing branches.

There are circumstances which may require a departure from the rule. For example, an injury involving the axillary high up, accompanied by much swelling from blood and inflammatory products, will be best treated by opening the neck and securing the subclavian external to the scalenus muscle, as such a course would necessitate a less extensive division of tissues, and would include a part of the vessel which is some distance from any branches. Again, in a wound at the upper part of the forearm, near the elbow-joint, in which the vessels had been previously tied at the seat of injury, but in consequence of a soft, œdematous, and sloughing state of the soft parts, secondary hemorrhage has taken place, it is better to tie the brachial above the articulation.

Wounds of the Hand.—Wounds of the palmar arch or of its branches form no exception to the general law above mentioned. It has been recommended in these injuries to tie that vessel in the forearm which, on being compressed, arrests the bleeding; but when it is considered that between the palmar arches and the radial, ulnar, and interosseous arteries a free intercommunication of branches exists, which branches are singularly uniform in their size, the unsoundness of such a practice will be obvious. When the wound is small, difficulty is sometimes experienced in placing the ligature securely on the bleeding vessel, the thread slipping off when the tenaculum is withdrawn. In such cases an instrument in which the handle and a part of the shank can be detached from the curved extremity (Fig. 245) will be found

Fig. 245.

Tenaculum.—Handle capable of being detached at *a*, from the point.

very useful, as the latter may be allowed to remain in the opening until the ligature becomes separated by ulceration, when both will come away together. When the opening is not sufficiently large to allow free access to the bleeding trunk, it should be enlarged to the required extent. In making incisions for this object, no thrusts are allowable. The surgeon must understand the distribution of the vessels, and with such a knowledge he may proceed with entire confidence to expose the deep part of the hand. The skin must first be divided, and next the superficial fascia, when the palmar aponeurosis will be brought into view, which can be readily recognized by its white, tendinous appearance. The important vessels are all beneath this structure. To open this membrane safely, a slight puncture should be made through its substance, and a grooved director introduced, by means of which the fascia can be raised from the vessels and nerves beneath, and its successful division

accomplished, giving an exposure of the parts sufficiently ample for securing any wounded vessel.

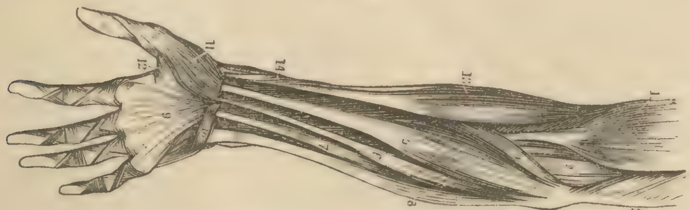
After tying vessels belonging to the palmar arch, or the arch itself, and particularly where the tissues are somewhat unsound, the force of the blood-stream in the hand should be diminished by placing oblong compresses over the radial and ulnar arteries and securing the same in position by a roller, beginning at the hand and extending up to the elbow; or, if the pressure of a bandage be painful, the object may be attained by elevating the arm and flexing it to an acute angle.

In the treatment of lacerated wounds of the hand, whether caused by machinery or by the bursting of fowling-pieces, the surgeon must consider well his case before having recourse to amputation. The vitality of the upper extremity attains its maximum in the hand. Here are concentrated the branches of three considerable arterial trunks, having an intimate inosculation with one another; here also is a rich supply of nerves; and here are the insertions of thirty-six muscles. All these components are supported by a skeleton consisting of some twenty-seven small bones, with curiously-contrived articulations, well calculated to combine solidity with mobility, and having a large continuous surface of synovial membrane. It is the vital energy necessary to move harmoniously such a combination of parts which confers on the human hand its singular power to resist injuries and repair the most extensive mutilations. Indeed, unless in cases of utter disorganization of all the components of this part of the limb, I never despair of its recovery.

In the treatment of lacerated wounds, no remedy compares in value to irrigation. At first the water should not be applied too cool, for fear of lowering the circulation below that degree necessary for the work of separating the damaged fragments of tissue and of reconstructing the injured parts; but as these processes advance, less attention is necessary on this point. Bleeding from the digital arteries which lie along the borders of the finger is easily controlled by pressure made with a compress and a narrow roller.

Punctured, poisoned, and contused wounds of the hand are frequently followed by deep-seated abscesses, which prove excessively painful, are accompanied by severe constitutional disturbance, such as rigors, fever, headache, sleeplessness, and entire loss of appetite, and, unless promptly treated, produce the most extensive disorganization of structure, leaving the member stiff, distorted, and withered. These palmar abscesses may be situated in four localities: first, in the subcutaneous tissue, in which locality they are least harmful, as they readily come to the surface; second, beneath the middle chamber of the palmar fascia, which corresponds to the hollow of the hand; third, under the thin expansion of this fascia which covers the muscles that form the ball of the little finger; and, fourth, under a similar extension of

Fig. 246.



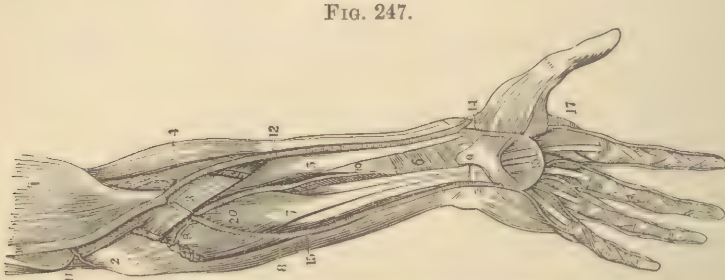
Palmar fascia, strong in the middle and less so at its margins.

the palmar fascia which spreads over the muscles constituting the ball of the thumb. (Fig. 246.) The great strength of the central portion of the palmar aponeurosis and its membranous connections with the two middle metacarpal bones renders purulent collections in the second position exceedingly dangerous to the welfare of the hand. The medical attendant is often misled in

such cases, as the resistance encountered by the inflammatory products on the palmar surface serves to force them upwards beneath the annular ligament of the wrist into the arm, or directly backwards between the interosseous spaces to the back of the hand. Hence, in these abscesses, though the disease begins in front, the swelling is greatest over the posterior surface of the metacarpus. Even when the case is clearly appreciated, the physician will often have some timidity in adopting the proper line of practice (which consists in laying open the palm of the hand), for fear of wounding the superficial palmar arch or its branches.

The lowest point reached by the curve of the arch corresponds to a line starting at the junction of the thumb and index finger and drawn directly across the palm of the hand to its ulnar border. An incision may be carried up to this line with safety. The digital arteries given off by the arch, and destined to supply the fingers, pass down opposite to the interosseous spaces and divide at the interdigital clefts, sending branches along the sides of the fingers. (Fig. 247.) Incisions, therefore, which are made over the middle

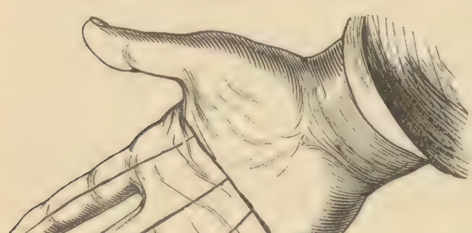
FIG. 247.



Superficial palmar arch and its digital branches.

of the palmar surface of the fingers, and over the course of the metacarpal bones, may be continued upwards safely to the transverse line. (Fig. 248.) The recognition of these facts, and the exercise of care in incising the integument and in raising the palmar fascia upon the director before its division, will enable the operator to execute his task without danger.

FIG. 248.



The transverse line indicates the lowest point of the palmar arch, and the vertical ones the positions free from vessels.

Punctured wounds of the hand are not unfrequently followed by a slow contraction of the tendons or of the palmar aponeurosis, causing deformity of one or more of the fingers.

In all cases of injury of the hand in which a palmar splint is employed, the padding should be formed so as to allow the fingers to be slightly flexed.

WOUNDS OF THE NERVES will be indicated by loss of motion and sensation in the parts to which they are distributed, thus enabling the surgeon to designate the particular trunk involved. Such injuries are not altogether hopeless, as the divided ends occasionally unite and the nerve resumes its function, the paralysis disappearing. We are not yet sufficiently informed on the subject of the regeneration of neurine to determine how wide a chasm between the retracted ends of a nerve-trunk can be bridged with material capable of conducting motor and sensory impressions. In one instance I resected over an inch of the ulnar

nerve above the elbow for a violent neuralgia of that part of the arm supplied by its branches, and with complete relief to the patient. Seven years after, partial power was regained in the muscles paralyzed, and with this restoration of function the pain returned again with great severity. We do know, however, that the nearer the extremities are brought in contact the greater will be the probability of obtaining a useful union. With this view it has been suggested to suture the ends of divided nerves; but I doubt not that these cords would resent such liberties. The evil effects of including a nerve in a ligature, or of transfixing it with a pin, are very well known, and sewing together its divided ends does not materially differ in the amount of injury inflicted. In cases where a nervous cord of importance has been cut, it will be best to endeavor, by deep stitches passing near to the trunk or even including its sheath, and by position, to effect the nearest possible approximation.

Contusion of the ulnar nerve in the groove between the internal condyle and the olecranon process of the ulna is a common occurrence. The sensations of numbness and tingling experienced in the little finger and the ring finger, with the unpleasant glow of heat which succeeds the injury, are well known. The effect of such contusions is generally transient, passing over in a few moments; though when the violence has been severe the inside of the elbow and arm may become swollen and painful, and the function of the fingers supplied remain suspended for some time. In such cases cold anodyne lotions may be applied at the seat of injury; and if the symptoms do not yield in two or three days, a blister should be laid over the contused nerve, with a view to remove the inflammatory thickening of its sheath.

Punctures of a branch of the internal cutaneous nerve where it is distributed over the median basilic vein—an injury which was not uncommon when venesection was more generally practiced than at present—may be followed by a red and painful condition of the arm. Anodyne lotions and a blister constitute the proper remedies.

Punctures of the digital nerves will sometimes cause the most exquisite tenderness, pain, and disability in one or more of the fingers. These symptoms may not set in until months or even years after the accident. After a time the skin becomes glossy, having a dull-red or purple color, and the affected member stands off from the other fingers in an awkward, helpless manner.

Where only a single digit is involved, excision of the digital nerves will be indicated; but when most of the hand suffers, the median or the ulnar above the wrist-joint will require excision.

There is a pseudo-neuralgia of the fingers occasionally met with in females. I have never witnessed a case in which more than a single digit was affected. This "mimicry," as it has been termed by Mr. Paget, when located in joints, can be distinguished from true nerve-trouble by the absence of the glossy and dull-red skin which characterizes the latter, and also by the fact that, when the patient's mind is attracted from the hand, no difference can be detected in the position or in the movements of the affected from the other fingers.

Wounds of the Lower Extremity.

The same general principles which are applicable to the treatment of injuries of the upper extremities are to be observed in those which involve the lower. The great blood-vessels of the thigh being situated at the anterior and the inner portions of the limb, wounds taking effect in these regions are attended with the greatest danger. In the ham the popliteal vessels lie deep, and are protected by being on the posterior aspect of the thigh: consequently they are rarely the subject of traumatic violence.

In the leg the anterior and posterior tibials, except in front and behind the inner ankle, are very slightly exposed to external injury, except from

gunshot missiles. It occasionally happens that in compound fractures of the leg these vessels are torn. Punctured and other wounds of the foot are frequently followed by tetanus, and the same may be affirmed of similar injuries of the hand.

Wounds of the foot should be treated in the same manner as wounds of the hand.

Wounds of the articulations will be considered under the head of Diseases and Injuries of the Joints.

CHAPTER VI.

DISEASES OF THE ABDOMEN.

Diseases of the Umbilicus.

Hemorrhage.—Bleeding from the umbilicus of new-born children, after the separation of the ligature from the cord, occasionally occurs, and in some instances becomes very serious in its consequences. When the hemorrhage is obstinate, it is ordinarily associated with some vice of the general system, and in a majority of cases will prove fatal. The treatment consists in first attempting to arrest the flow by astringents, such as alum, the subsulphate of iron, or styptic cotton. Should these not succeed very soon, it will be necessary to resort to some more decided measures, as infants bear the loss of blood badly. The actual cautery or the solid nitrate of silver may be applied to the bleeding surface, or a pin may be pushed through the base of the navel and surrounded by a ligature.

Ulceration.—This is met with both in infants and in adults. In the former after the separation of the ligature from the cord there is left a raw stump which refuses to heal, from which purulent matter is discharged, and which also, when rudely touched, bleeds quite freely. In adults excoriation and ulceration arise, either from negligence in keeping the parts clean, or, in very obese persons, from the contact of adjoining surfaces, by which the cuticle becomes macerated and detached in the retained perspiration. The best remedies in all these cases are frequent ablutions, and dusting the parts with calomel and prepared chalk (equal parts). If this fail, the surface of the ulcer should be lightly touched every three or four days with the nitrate of silver or with iodoform.

Morbid growths.—Fibrous growths, though quite uncommon, are occasionally seen to spring from the bottom of the umbilical depression. Their attachment is either pedunculated or sessile, and sometimes extends beyond the circumference of the navel. They are smooth upon the surface, firm, and inelastic to the touch. A more common growth is one consisting of hypertrophied cutaneous papillæ,—a variety of papilloma,—the surface of which is irregular, consisting of rod-like eminences, and often becoming foul with offensive discharges. As long as these tumors remain quiet they should be left alone, or at most be carefully cleansed. When they continue to grow, their removal may be accomplished by the scissors or knife, or by strangulation with a ligature. When their attachment is pedunculated, the latter answers every purpose. By whatever method they are taken away, the surface left should be treated with nitric acid, or caustic potash, to prevent a return.

Cysts.—A collection of fluid sometimes takes place between the peritoneum and the abdominal parietes,—a form of encysted dropsy,—which, should it happen to be beneath the umbilicus, may protrude that structure and form an external swelling. This cannot, however, be properly considered an umbilical cyst. Such enlargements may be confounded with hernia. A case was related to me in which an attempt was made to remove what was supposed to be such a cyst but which proved to be an umbilical hernia. The reducibility of hernia, at least in its early history, and, in most instances, its resonance, neither of which belongs to cysts, will assist in establishing a distinction

between the two diseases. A resort to the aspirating-needle will also serve, in some degree, to clear up doubts. Tapping and the injection of iodine will be the proper treatment when the disease is progressive.

Carcinoma.—The most common form of malignant umbilical disease is epithelioma; but I have recently seen what I believe to be a true scirrhus of this part. The growth of malignant disease is characterized by induration, pain, and a pimply, lilac discoloration of the skin. It may develop both internally and externally. The skin sometimes becomes inflamed, and ulceration follows, constituting a very offensive and spreading sore. Unfortunately, the surgeon's duty is limited to directing such agents as will promote cleanliness, relieve pain, and sustain the system. No operation will effect any good whatever.

A variety of fistulæ occur at the umbilicus, some of which are congenital, and others inflammatory, in their origin. They are as follows:

Urinary fistula.—The urachus may remain open at birth, and the urine escape at the umbilicus, forming a fistula. An early effort should be made to secure its closure by applying to its orifice nitric acid on a silver probe. A child was once brought to my clinic in which the urachus had not closed. There was no fistulous opening in the umbilicus, but the latter became distended when the urine was allowed to accumulate in the bladder. I am unable to say whether the defect proved permanent.

Stercoraceous fistula.—In consequence of a blow over the umbilical region a limited peritonitis may be developed, and a portion of intestine become glued to the parietes posterior to the navel. This may ulcerate and open through the latter. The opening requires to be kept free from obstruction, and after a few weeks, should the fistula show no tendency to close, an attempt may be made to close it by freshening the edges and uniting them with the twisted suture.

Ovarian fistula.—I saw in a distant part of Pennsylvania, in the person of a lady, an umbilical fistula which communicated with the right ovary. At the time of my visit it was obstructed with rolls of hair; fragments of bones were also occasionally discharged. The cause leading to this fistula was a very tedious and difficult labor, followed by pelvic cellulitis, after which the swelling and ulceration at the umbilicus took place. Such cases are best left to nature, only observing to keep the channel clear when signs of obstruction exist.

Ascites.

Ascites is a collection of fluid in the peritoneal sac. It may be *obstructive* or *inflammatory.*

Under the head of obstructive causes may be enumerated disease of the liver, spleen, kidneys, omentum, and heart; also the presence of ovarian and uterine tumors. Whatever tends to retard the flow of blood through the vena cava ascendens favors the production of the disease. The inflammatory origin of ascites is peritonitis, generally of a chronic form and excited by mechanical pressure. Thus we frequently see large accumulations of fluid follow the presence of an ovarian cyst, uterine growths, and malignant disease of the omentum. As these roll about in the abdomen, rudely rubbing against the surfaces of the peritoneum, they provoke an inflammation which is followed by the transudation of serum. The serous membrane is often much thickened from this kind of irritation. Acute peritonitis, should the patient not die from shock during the stage of development, is attended with more or less serous effusion.

The abdominal fluid in ascites is usually of a straw color, not unlike that present in hydrocele. It coagulates by heat, is somewhat unctuous to the feel, and contains various saline matters. When it is the result of acute peritonitis, the fluid differs in many particulars from that which has an obstructive origin or which is caused by chronic inflammation. In the first, it has a reddish tinge or presents a dirty-brown appearance, with a sickening odor,

and contains numerous flakes of lymph, and also purulent matter. It is a dangerous fluid, and seems charged with a highly active poison, often producing, when applied to a scratch or a puncture, severe local and general disturbance.

Symptoms.—Abdominal dropsy usually appears in a gradual manner. It is preceded by œdema about the ankles and feet, which slowly extends up the leg and thigh and sometimes to the integument of the penis and scrotum. In Bright's disease of the kidneys, it is not uncommon to see the connective tissue of the entire surface, from the roots of the hair to the soles of the feet, filled with serum, as are also the serous-lined cavities of the body. If pressure be made for a few moments with the finger upon the œdematous parts, the fluid will be displaced, and a depression will remain for some time after. This is called "pitting." Those portions of the body on which rests its weight in sitting or in lying will often, for the same reason, present large indentations.

As the fluid accumulates in the abdomen, its anterior and lateral walls become distended. This distention is first seen at the lower part of the body, towards which the fluid naturally gravitates. The height of the collection can be very clearly ascertained by placing the patient in the upright position and percussing the abdomen from above downwards. The line at which the resonance ceases and the sounds become flat will indicate the position of the effusion. The fluid does not float the intestines forward, but occupies the space between the bowels and the parietes. If the fingers be placed on one side of the abdomen and the opposite wall be lightly tapped with the other hand, fluctuation may be recognized, becoming more and more distinct as the distention increases. As the disease advances, the fluid at length presses against the diaphragm, thus resisting the descent of this muscle in respiration, causing great difficulty of breathing, and compelling the patient to maintain the sitting posture in bed; the urine diminishes in quantity, the appetite fails, the pulse becomes frequent and feeble, emaciation progresses, and the sufferer finally dies from exhaustion.

Diagnosis.—Ascites may be confounded with ovarian disease, with pregnancy, with distended bladder, and with abscess. From ovarian dropsy ascites may be distinguished by the previous history of the patient, the former disease being generally very slow in its progress and not seriously involving the general health for a long time after its appearance, while in the latter, impaired health often precedes, and always accompanies, the abdominal swelling. Not only so, but a careful interrogation of the internal organs will generally reveal some structural change as the cause of the dropsy, such as valvular disease of the heart, cirrhosis of the liver, or disease of the kidneys, as manifested by the presence of albuminous urine and casts from the uriniferous tubes. The position of the swelling in its incipiency will also throw light upon the subject, being median in ascites and unilateral in ovarian dropsy. In the latter the sac is frequently multilocular, the constrictions corresponding to the partition-walls of the cyst, and the irregularities of its surface may be distinctly felt through the parietes of the abdomen. In ascites the fluid, when in large quantity, presses out the flanks, while in ovarian disease there is an absence of this bulging, the projection being for the most part directly forward. When the practitioner remains uncertain in his diagnosis, an exploring-needle or trocar may be introduced with a view to examine the appearance of the fluid, which in ascites is ordinarily thin and of a straw or amber color, whereas that from ovarian cysts, with now and then an exception, is ropy, viscid, thick, even gelatinous in consistence, and has a dark-yellow or brown color.

From pregnancy, ascites may be distinguished by the following considerations: in the former there are nausea, vomiting, capricious appetite, enlarged mammary glands, brown discoloration around the nipple, a firm, inelastic, uniform swelling in the median line, a flat percussion without fluctuation, absence of the menstrual discharge, and finally the sound of the fœtal heart, together with the test of "ballottement." The general health in pregnancy

is not much disturbed; in ovarian dropsy there is usually loss of flesh and strength.

To confound ascites with a distended bladder is a mistake not likely to occur; yet the error has been committed, as I have reason to know. In distended bladder there is more or less desire to pass urine, the patient frequently making ineffectual efforts to micturate, attended with much distress about the penis and bladder; the swelling is median, smooth, without fluctuation, and may be felt through the walls of the rectum. It also attains a considerable size in from twenty-four to thirty-six hours. Should any doubt remain, the introduction of a catheter will solve it by simultaneously removing the contents of the bladder and those of the tumor.

Abscess in the walls of the abdomen may simulate ascites, chiefly from the presence of fluctuation. The unilateral position, and the occurrence of chills, with perspiration and other hectic symptoms which belong to the former, will serve to establish the distinction. The exploring-needle here, as in many other swellings, will render the diagnosis clear.

Prognosis.—The prognosis is exceedingly unfavorable, as the disease generally depends upon structural change in organs, such as the heart, kidneys, and liver, over which our remedies have little control.

Treatment.—The indications in the treatment of ascites are to remove the fluid and to correct, as far as possible, the causes which give rise to its production. There are two methods of accomplishing the first,—that is, the evacuation of the fluid,—namely, the therapeutic and the operative. In employing the first of them we aim to act chiefly upon the skin, the kidneys, and the intestinal canal, or upon all. In order to stimulate the kidneys, in my experience there is no better diuretic than the infusion of digitalis. A dessertspoonful should be given every four or five hours until the secretion of urine is largely increased. Or it may be necessary to combine a cathartic and diuretic. A very popular combination is bitartrate of potash and juniper-berries. Where the patient is not too much exhausted, the old formula of Eberle I have found to answer an admirable purpose:

℞ Potassii Bitartratis, ℥iss;
Potassii Sulphatis, ℥ss;
Pulveris Scillæ, ʒii;
Antimonii et Potassii Tartratis, gr. i.
M.—S. One teaspoonful every four hours until active purgation and diuresis follow.

When the abdominal dropsy and œdema are due to cardiac disease, the use of small doses of calomel, with squill and digitalis, often does much good:

℞ Hydrargyri Chloridi Mitis, gr. v;
Pulv. Scillæ,
Pulv. Digitalis, āā gr. xx.
M.—Ft. chartulæ no. xx.
Sig.—One powder four times a day.

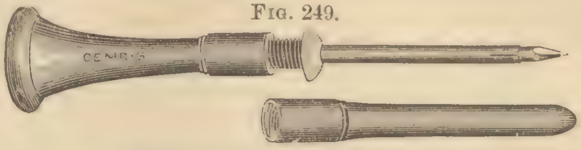
In many cases, however, neither diuretics nor hydragogue cathartics will make any impression upon the disease, the pressure exerted upon the kidneys and other organs within the abdomen by the fluid defeating their action. In such an event it becomes necessary to resort to operative measures.

Paracentesis Abdominis.—This operation, though a very simple one, should not be undertaken until the distention becomes a source of marked distress, or is accompanied with obstinate vomiting, a condition more common in ovarian than in abdominal dropsy. The proper point at which to puncture the abdominal wall is in the median line, about two inches below the umbilicus. A trocar and canula (Fig. 249), a thumb-lancet, a basin, and a strip of adhesive plaster, with a four-tailed bandage sufficiently long to go twice round the body and broad enough to include the entire surface of the abdomen, are all that is required for the operation.

The only caution which need be given in the use of the trocar, is to be sure

that the intestine does not lie in contact with the abdominal wall at the place where the instrument is made to enter. Carelessness on this point has resulted in a wound of the bowel.

Fig. 249.



Trocar and canula for tapping the abdomen.

In abdominal dropsy the fluid occupies the space between the viscera and the parietes, and it is on account of this circumstance that the puncture can be safely made. When, therefore, the percussion is entirely flat, no apprehension need be felt in introducing the trocar.

The patient, having emptied the bladder, may sit upon the edge of a bed, with the feet resting upon a stool and the back supported either by pillows or by a friend, or, if too weak to maintain the upright position, may lie on the side, close to the edge of the bed. The body of the bandage being now placed over the front of the abdomen, the tails are to be crossed behind the back, those on the right passing over to the left and those on the left passing over to the right, and are given to an assistant on each side. The surgeon then makes an opening in the body of the bandage over the median line, two inches below the umbilicus: through this he punctures simply the skin with the thumb-lancet, and immediately thrusts in the trocar, guarded by the index finger fixed one inch and a half from the extremity of the instrument (Fig. 250), pushing it onwards until all resistance is overcome, when it should be withdrawn, leaving the canula in place. The fluid should be received into

Fig. 250.

Tapping in abdominal dropsy.

a basin, and when the latter is full the operator can place a thumb or finger against the extremity of the tube, temporarily arresting the flow until the vessel is emptied into some receptacle and returned, when the fluid may be again allowed to discharge. As the accumulation is withdrawn, the bandage should be tightened up by drawing upon its tails, thus supplying to the viscera and blood-vessels the pressure which they have lost from the abstraction of the fluid, and in this way preventing that sense of sinking or fainting which occasionally follows tapping. Should the patient grow pale, sick, and weak during the operation, a little brandy-and-water may be given, and, if in the sitting posture, the position may be changed to one on the side. The canula may become obstructed from a loop of intestine, or from masses of lymph or from blood-clots causing an impediment to the flow: in such an event a

change in the position of the instrument, or a knitting-needle or probe passed through its canal, will serve to clear away the obstruction. As soon as the fluid has been discharged, the canula should be removed, the opening covered with a strip of adhesive plaster, and the tails pinned either to one another or to the body of the bandage.

There are trocars in use which differ from the one described by having a branch-pipe, to which a piece of rubber hose can be attached, for conducting the water into a vessel under the bed or out of the way. (See Fig. 229.) An aspirator also answers the purpose admirably.

Encysted dropsy of the abdomen is occasionally met with,—that is, an accumulation of serum cut off from the general peritoneal sac. The circumscribing walls of these cysts are the result of a chronic peritonitis. In three cases recorded by Dr. William Pepper,* the cause was doubtless traumatic, and was most probably due to the stimulus of coagulated blood within the peritoneum. The walls of these cysts may be constituted in various ways: sometimes they are formed by the peritoneum in front and the omentum behind; sometimes by the omentum in front and a portion of the intestines posteriorly, a number of coils having been glued together by inflammatory lymph; and in other instances by the folds of the omentum alone. The fluid which they contain is clear serum. These cysts may be converted into purulent sacs, as in the interesting case reported by Dr. Mears,† in which two gallons of a purulent fluid were drawn from a cyst between the omentum and intestines. In a similar case I drew over three gallons from a cyst on the right side of a female patient.

The existence of such cysts will be indicated by the circumscribed character of the swelling, by their yielding a flat percussion-sound, and by the surrounding portions of the abdomen being resonant; also by the fixed position and unchanging character of the enlargement, in whatever position the patient may be placed. When transformed into a pus-cavity, there will be a history of previous chills and possibly hectic symptoms.

The treatment of encysted dropsy consists in evacuating the fluid by the trocar or aspirator, as in abdominal dropsy. The tapping may require to be repeated, and, if there follows a steady diminution in the size of the swelling, nothing else may be required. When cysts suppurate, it will be best to open them, evacuate the contents, and treat by drainage-tubes and carbolic acid water.

Foreign Bodies in the Stomach.—Foreign bodies frequently enter the stomach, either by accident or by design. Writers have divided these bodies into round, flat, pointed, and irregular; and this division is one of practical importance. Round bodies, such as bullets, marbles, and pebbles, are frequently swallowed. A boy playing with a marble in his mouth allows it, in an unguarded moment, to slip down the œsophagus into the stomach. In this manner also coins are frequently swallowed. I have known a person to swallow in succession seven or eight large bullets as a matter of amusement. Knives, forks, and pins have also slipped into the stomach, both with and without the consent of the patient. The insane are much given to the habit of bolting bodies of an unusual character.

A case is reported‡ in which a soldier was shot in the abdomen, the ball entering the stomach, in the cavity of which it was found. Bodies like pins or needles, if they succeed in reaching the stomach, may make their way through its walls and travel to distant points, much in the same manner as when broken in external parts of the body. In this way may be explained the presence of foreign substances in unusual situations.

Round bodies make their way out of the stomach and through the intestinal canal more easily than such as have an angular, elongated, or irregular shape. Articles of unusual size and form will succeed in passing the pyloric

* Transactions of the College of Physicians, vol. i. 3d ser., 1875, p. 181. † Ibid., p. 171.
‡ Surgical History of the War of the Rebellion, Part II. vol. ii.

orifice of the stomach, which, independent of observation, we could scarcely credit. I published, some years ago, a very remarkable case of presence of foreign bodies in the intestines. It occurred in a female subject which I was examining in the dissecting-room of the Philadelphia School of Anatomy. Scattered along the intestinal canal from the jejunum to the rectum were found the following articles: three spools of cotton, the thread partially unwound; two roller bandages, one two inches and a half wide and about one inch thick, while the other had become partially unrolled, one end being in the ileum and the other in the rectum; a number of skeins of thread, a quantity being packed tightly in the cæcum; and, finally, a pair of suspenders. I afterwards learned that this woman had been insane.

Mr. Bryant speaks of a stomach, very much thickened, in Guy's Hospital Museum. It was that of a sailor who had been in the habit of swallowing clasp-knives. This man had at different times disposed in this manner of no less than twenty knives. Finally the blade of one perforated the colon and destroyed his life. Several blades were found, partially eroded, in the stomach.

Mr. Taylor, of Edinburgh, narrates the case of a patient who swallowed an artificial plate with six teeth, which was passed by the anus three days afterwards.

Treatment.—The physician is often applied to by parents in great alarm in consequence of a child having swallowed a piece of coin or a marble. Though I have known a number of such cases, in no instance can I recall any evil consequences resulting from the accident.

The practice of exhibiting a cathartic immediately after the foreign substance has been swallowed is to be deprecated. A body hurried along the intestinal tube in the current of glandular secretions, and under the energetic peristalsis excited by the purge, may, especially if it be rough, seriously damage the mucous and other tunics of the bowel. It should be left for two or three days to the physiological processes of the stomach and intestine, which generally serve to carry it forward, and at the same time to encase it with feculent matter, rendering its surfaces harmless to the bowel, after which, if it is not passed spontaneously, a cathartic may be administered of such nature as will produce a consistent evacuation, the best being a mixture of sulphur, senna, and the bitartrate of potash,—half a drachm of each being taken in a little syrup.

When the body is one the passage of which is very improbable, such as a knife or fork, and which is liable to produce inflammation, ulceration, and perforation of the organ, or to excite a destructive peritonitis, the question of opening the stomach and extracting the body will arise. When performed for this purpose, the operation is called *gastrotomy*, from the Greek words γάστηρ, the stomach, and τέμνω, to cut. When the stomach is opened with a view to establish a gastric fistula through which to introduce nutritious substances, the operation is termed *gastrostomy*,—literally, a belly-mouth. The conditions which have suggested this operation are impassable strictures of the œsophagus, from cancer and other causes. Gastrotomy for the removal of foreign substances should not be undertaken without substantial and urgent reasons, seeing that bodies of unusual size and form do pass safely through the intestinal canal. Durham has collected seven cases, and Pooley* four, all of whom, with a single exception, recovered.

The propriety of gastrostomy is still a debatable question. Its object is a humane one, it being undertaken not to cure the disease, but to prolong life. Mr. Durham has collected nine cases, which, with the one of Dr. Maury† and that of Dr. Lowe, make an aggregate of eleven, ten of whom are known to have died, and the eleventh most probably did so, as the result would likely have been reported if successful. In each of these eleven cases life was shortened,—except in perhaps a single one, who survived thirty days. This, when taken

* Richmond and Louisville Medical Journal, April, 1875.
† American Journal of the Medical Sciences, April, 1870.

in connection with the fact that the ulterior motive at best is but palliation, makes such a surgical procedure unjustifiable. The plea that life, even if shortened, was rendered more endurable, is entirely untenable. No amount of palliation can ever be set over against the subtraction of a single day from the life of a fellow-being.

Operation of Gastrotomy.—This operation was first performed by Sédillot. When it is contemplated to open the stomach, no solid food should be taken by the patient for thirty-six hours before the operation, and for six or eight hours not even liquids, in order that the viscus may be empty and the risk of extravasation be thereby diminished. Even with the possibility of vomiting, it is better to administer ether or chloroform to insure entire quietude. The patient being placed upon the back, an incision should be made four inches in length, commencing at the linea semilunaris, near to the cartilaginous border of the chest, and extending obliquely downwards and outwards parallel with the same. After the incision through the integument, the remaining layers, fascial, tendinous, muscular, and peritoneal, should be lifted in succession, and divided upon a grooved director. This done, the left, or pyloric, extremity of the stomach will be brought into view, which should be fixed and retained at the wound, either by pinching up a fold with the fingers or by passing a thread through its coats. The surgeon then divides the anterior wall of the organ in the direction of the external wound to an extent sufficient for the extraction of the foreign body, which is best accomplished by a pair of polypus or gullet forceps. The wound in the viscus should now be closed by Lembert sutures, and the opening in the parietes united by deep interrupted stitches, with silver wire. During the operation the utmost care should be observed to prevent either blood or the contents of the stomach from entering the sac of the peritoneum. All vessels, therefore, must be tied and the bleeding allowed to cease before the parietal layer of the serous membrane is divided, and an assistant must be ready with a soft, warm, and moist sponge to receive any matters which may escape from the organ.

During the after-treatment the shoulders of the patient should be kept somewhat elevated, and the lower extremities flexed over a pillow. No food, liquid or solid, must be allowed to enter the stomach for eight or ten days after the operation. All nourishment should be administered by the rectum during this time. After the lapse of ten days, milk and beef-essence may be taken, in small quantities at a time, by the mouth.

When the object is to establish an artificial opening or gastric fistula, the incision through the walls of the stomach will require to be made larger than in the operation of gastrotomy, and the edges of the opening must be stitched to the margins of the parietal wound.

Intestinal Obstruction.

One of the most difficult subjects within the whole range of surgical study is that of intestinal obstruction. I am never called to a case of this nature without feeling that I am to approach a subject environed with conjecture and embarrassment. By intestinal obstruction is meant the existence of any obstacle to the passage of the fæces along the bowel.

The causes which operate to produce this result are numerous, but may be arranged under two heads: *acute* and *chronic*.

Acute intestinal obstruction.—Under this head are included all cases which come on suddenly and run a rapid course. Some of these are congenital, and others are acquired. The most common congenital cause is imperforate anus, or absence of the lower portion of the rectum,—a subject which will be considered with diseases of that portion of the intestinal tube. Dr. Wilks* describes a rare form of congenital constriction which affects the duodenum of infants, and is attended with constant vomiting.

* London Pathological Transactions, vol. xii. pp. 101, 121.

Intussusception or invagination.—In this form of obstruction the upper part of a portion of the intestine slips into a segment of the gut below, very much as the finger of a glove is turned back upon itself. (Fig. 251.) It may take place at any portion of the small or large intestine, and is sometimes multiple, existing at two or more points in the course of the bowel. Some writers have denied that intussusception ever occurs in the small intestine. I have myself seen it involving this part of the bowel in several places, and in Mr. Gay's collection of cases* it was found thirty-three times in this part of the tube, though it is situated usually at the ileocæcal union. It may involve only three or four inches, or it may include a large amount of the bowel. The invaginated portion is constricted at some point by the circular muscular fibres of the intestine, giving to the affected part an hourglass appearance. The cause of intussusception is obscure, probably from some irregularity in the distribution of nerve-force and the result of reflex irritation. It is not confined to any period of life, or to either sex.

Fig. 251.

A portion of the ileum invaginated.

Symptoms.—The occurrence of intussusception is followed immediately by abdominal distress or pain, usually confined to a limited space, though it may be diffused over the entire abdomen. There is a desire to evacuate the bowels, but all efforts for this purpose result only in severe straining, with the passage of some tenacious or ropy mucus frequently mingled with blood, or of blood by itself. Occasionally a hard, circumscribed swelling can be detected through the walls of the abdomen, or a mass of invaginated mucous membrane may be felt in the rectum. Both of these conditions were present in the case of a child whom I saw with Dr. Potter, of Germantown. Should the case linger or tend to pursue a chronic course, the abdomen becomes distended and tender, which often announces the commencement of peritonitis. Vomiting is not a constant accompaniment of invagination, and has little diagnostic value as a sign of the disease.

Prognosis.—The prognosis is unfavorable, though numerous instances of recovery are on record, even under the most discouraging conditions. Should the patient survive the first severe shock attending the onset of the disease, he may afterwards die of peritonitis. Should this danger be successfully passed, the patient may recover,—a result, however, which can take place only by the sloughing of the strangulated part of the intestine and its discharge through the bowel below.

Fig. 252.

Intestinal twist.

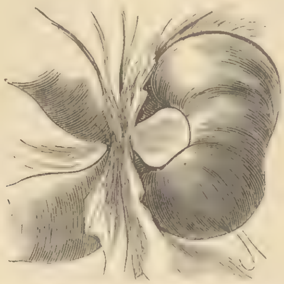
Intestinal twist, or volvulus.—A loop of intestine is sometimes twisted upon itself, the mesentery or mesocolon forming its axis, until the canal of the bowel is completely obstructed (Fig. 252), a condition which is supposed to be due to a redundancy of the mesentery or mesocolon. The sigmoid flexure of the colon most frequently suffers from volvulus. The symptoms are in many respects like those of intussusception. Erichsen thinks that in this form of obstruction the two sides of the abdomen are not symmetrical, one side, the affected, being more distended than the other.

Strangulation by circumferential constriction.—This may follow from a loop of intestine slipping through an opening or a slit in the bands left by an old peritonitis, or it may result from the bowel becoming encircled by a process of omentum. In one case which I examined, the ileum was strangulated by the appendix vermiformis, the free

* Trans. Med. Soc. London, 1861–62.

extremity of which had become adherent to the cæcum. (Fig. 253.) The diverticula or worm-like processes which are occasionally seen projecting from the intestine sometimes occasion a fatal strangulation. Obstruction is also often caused by bands of organized lymph constricting the intestine so as to prevent the passage of its contents. (Figs. 254, 255.)

FIG. 254.



Obstruction from a fibrous band.

FIG. 255.

Obstruction by a band of inflammatory lymph.

FIG. 253.

Strangulation of the ileum by the appendix vermiformis.

Acute peritonitis.—An acute attack of peritonitis may so completely paralyze the muscular walls of the intestines as to destroy all peristalsis and produce obstruction. In such cases the difficulty arises from the loss of function, not from any mechanical impediment. When death follows an attack of this kind, it is due to the serous inflammation, and not to the retention of fæcal matter. Inertia of the bowel from this cause is characterized by great tenderness and tympanitic distention of the abdomen, a dorsal decubitus, with flexion of the limbs, and a hard, contracted, and frequent pulse.

Chronic or Slow Obstruction.—In this form of the disease the causes, whatever they may be, operate slowly. Among these the following may be mentioned:

1. *Accumulations of fæces or of foreign matters.*—Obstruction from feculent accumulations is not uncommon. When present, it is due to carelessness in securing regular alvine evacuations. It is more often seen in women than in men, and more especially in those who are advanced in years and lead a sedentary life.

Obstruction occasionally arises from foreign bodies, such as hay, straw, rags, and other materials which have been swallowed. I have seen an immovable impaction produced in this way. Such cases are almost invariably met with in insane persons. In making an examination of the body of a lunatic, I once found the cæcum packed with hay and straw.

In cases of obstruction from fæcal impaction, there is usually an antecedent history of habitual constipation, extending perhaps over months, and which has been gradually becoming more obstinate. The patient has suffered occasionally from flatulence and colicky pains, but without any material change in the health.

When the accumulation finally culminates in obstruction, the abdominal pain, distention, and tenderness are not extreme, there is little shock, and often no vomiting. An examination of the abdomen will frequently detect through the parietes a hardened mass, with an irregular surface, which when strongly pressed upon becomes altered in form, and which yields when percussed a dull, flat sound. In a lady who suffered from constipation, I discovered a hard mass in the right lumbar region apparently the size of a large orange. Some months afterwards she discharged masses of intertwined worms, with the effect of relieving the bowels and removing the supposed tumor.

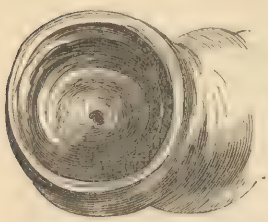
2. *Obstruction from organic change in the walls of the intestine.*—These changes may be either malignant or benign. The malignant or cancerous degeneration is in most cases, originally at least, confined to the large intestine. Not all portions of the large bowel are equally prone to be attacked. The rectum furnishes a large proportion of these cases, and next in frequency the sigmoid flexure of the colon. Even a certain portion of the rectum appears to be elected by the disease in preference to others, viz., that part about two and a half inches above the sphincter. When not in the large intestine, the pylorus is, especially in the aged, a favorite locality for the disease. Though the deposit may be irregularly disposed in the walls of the intestine, yet it is very often found assuming a singularly definite or ring-like form around the circumference of the tube. Sometimes it sends out profuse granulations, forming a fungus which fills up the cavity of the bowel and which bleeds freely when rudely handled. Fragments of this cauliflower mass frequently slough, and are discharged with the evacuations. The progress of this variety of intestinal cancer towards a fatal termination is usually rapid. In other instances the deposit takes place in the submucous connective tissue, raising the mucous membrane into irregular hard nodules, which gradually encroach upon the canal of the bowel and finally result in complete obstruction. This answers to schirrus or hard cancer. When the disease takes this form its progress is more chronic. In some few cases I have found the feature of irregularity or nodulation entirely absent, and the mucous membrane smooth, having lost its natural duplications or folds. If a finger be passed into the bowel, the induration will be found to be uniformly distributed about its circumference. These are the cases in which the patient possesses little power to expel the fæces, even long before the calibre of the tube is much narrowed, requiring injections to wash out the accumulations. This disability results from the cancerous infiltration of the muscular as well as the cellular coats of the bowel, whereby its contractility is destroyed.

No age is exempt from intestinal cancer, though it is more peculiarly a disease of advanced life. Obstruction from malignant disease is usually the work of many months, in some cases of years. A careful inquiry into the antecedent history of the patient will usually disclose the previous existence, for a long time, of dyspeptic symptoms, such as flatulence, sour eructations, oppression after eating, and colicky pains. There has also been a steady though not rapid loss of flesh and strength. If the deposit is in the neighborhood of the pylorus, or in some part of the small intestine, there will be vomiting of the food. When the disease is located in the large intestine, there will be pain and constipation, with alteration in the size and form of the fæces, the stools being sometimes small and round, and at other times angular or flat, according to the shape of the stricture; or the passages may be frequent and small, consisting of broken fragments of feculent matter, which are dislodged with difficulty and often only after several ineffectual attempts. In some instances blood, mingled with mucus and pus, or a watery, blood-stained fluid, having a highly offensive odor, is discharged from the rectum. The pain is severe, and often of a lancinating character. When the cancerous deposition is large, it may be discovered through the abdominal parietes, and when in the rectum, by an exploration with the finger.

There is also a structural alteration of the intestine producing obstruction

which has an inflammatory origin entirely free from malignancy, and which assumes very much the appearance of an annular valve similar to that at the pyloric orifice of the stomach, and gradually contracts until only a small orifice is left between the upper and the lower portion of the bowel. As far as my own observation extends, it is most common in the large intestine; and in one case which was under my care it followed a blow over the left side of the abdomen. The ring seemed to have been formed from the normal crescentic folds on the interior of the gut: it is represented in Fig. 256.

Fig. 256.



Annular stricture of the colon. From a young man who died from obstruction.

Cicatrices, which result from the healing of intestinal ulcers caused by chronic dysentery and other diseases, will also produce obstructions of a serious nature, from the inherent tendency of the new material to contract.

A very curious instance of obstruction having an inflammatory origin I saw with Dr. Frank Haynes, of this city. The patient had for many months been harassed with a chronic diarrhœa, which was finally succeeded by obstinate constipation and stercoraceous vomiting. There was no tympany: the abdomen remained flat and without any marked tenderness. At no time was there much disturbance of the circulation nor were any active symptoms present. The man steadily emaciated, and after three weeks from the commencement of the attack died. The last week of his life some liquid discharges from the bowels took place, having a faint odor of feculent matter.

On examining the body, coils of intestines were found adherent to one another and the entire canal converted into a rigid, inflexible tube. The inflammatory infiltration involved all the coats of the bowel, and had become organized to a degree which entirely destroyed the function of peristalsis.

3. *Obstruction from morbid changes in contiguous organs.*—A fibroid tumor developed from the posterior wall of the uterus may compress the rectum so as to prevent the passage of the fæces, or the weight of such a growth may, by retroverting the uterus, produce a like effect. Ovarian cysts have in some instances caused an obstinate obstruction from pressure.

The most common causes of intestinal obstruction are, first, peritoneal bands and diverticula; and, second, intussusception. In 135 cases collected by Mr. Hinton,* 36 were from the first-named and 24 from the last-named cause. Of Dr. Brinton's 600 cases,† 31 per cent. were produced by bands, 43 per cent. by intussusception, 17 by stricture, and 8 by twists. Of the 75 cases terminating fatally at Guy's Hospital, Dr. Fagge‡ says that 17 were from incarceration by adventitious bands. That intestinal obstruction forms a considerable proportion of the general mortality of a community is shown by the 12,000 autopsies analyzed by Dr. Brinton, in which one death in 280 cases was from this cause. In this estimate, death from strangulated hernia was not excluded.

While the signs of intestinal obstruction from the various causes have been enumerated, it is nevertheless true that they are so alike in all as to render a diagnosis one of great uncertainty. In attempting to reach the true origin of a given case, the first inquiry should be in regard to the invasion of the disease. Has it been sudden or slow in its development? If sudden, three causes will naturally present themselves,—strangulation, intussusception, and peritonitis. If the onset be sudden, the pain intense and localized about the umbilicus; if no hernial tumor can be discovered, or if a hernia have shortly before been reduced; if there be persistent stercoraceous vomiting and moderate abdominal distention, with marked prostration, the patient being over twenty years of age, there is good reason to conclude that the obstruction is due to strangulation from a band, a diverticulum, or a twist. The

* Assoc. Med. Jour., 1853. † Brit. Med. Jour., Jan. 1876, p. 431.
‡ Guy's Hospital Reports, 1868.

restriction of the pain to the left iliac region, together with the presence of the symptoms already detailed, indicates a volvulus or twist in the sigmoid flexure of the colon. The loss of symmetry in the two sides of the abdomen, if present, one being flat and the other distended, as alleged by Mr. Erichsen, will also denote this condition of the intestine. In three instances I have seen obstruction follow the sudden restoration of an old hernia.

If the patient be a child, the attack sudden, the pain severe and intermittent; if there be a frequent desire to stool, with tenesmus and vomiting, followed by a discharge of blood and mucus, such as occurs in dysenteric attacks; and if, in addition, the abdomen do not become increasingly tympanitic, with subsidence rather than increase of pain, and with perhaps the presence of an elongated tumor in the abdomen and possibly another in the rectum, the inference is that the case is one of invagination.

If a patient, previously enjoying good health, after a full meal of indigestible food, or after eating too freely of grapes, be seized with flatulence, and pain in the abdomen, with great tenderness and distention of its walls; if the bowels be obstinately constipated, without vomiting, and the pulse frequent, hard, and contracted; if the limbs be drawn up towards the body, the patient remaining rigidly upon the back, with a haggard and pinched countenance, the obstruction is in all probability due to peritonitis.

In slow or chronic obstruction, the disease is commonly located in the large intestine. The lower its seat in the bowel, the less will be the tendency to vomiting. The higher its location, according to some writers, the more will the urine be diminished in quantity. A portion of the large intestine can be examined by the eye or explored by the fingers, enabling the surgeon to detect any morbid growths which may exist within certain limits. This exploration has been extended even up to the colica media by carrying the hand and arm up into the bowel, as practiced by Simon. A surgeon should have very cogent reasons for resorting to such a procedure. It is altogether feasible, with a little patience, to pass the rectal tube as high as the transverse colon, provided no obstruction exists below that portion of the bowel. It is proper to state that there may be serious obstruction without a complete block of the bowel.

If in such a case the patient be a nervous woman, an aged man, or a young child, and there be a history of constipation, a constant desire to relieve the bowels without being able to pass anything more than a little fluid discolored by particles of feculent matter even though a cathartic has been administered, and if there be a sense of fullness and local distress in the rectum, the general health not being impaired, the case is probably one of fæcal impaction, and the use of the finger will verify or disprove this conclusion. It is not uncommon to meet with such rectal collections after typhoid fever and other exhausting diseases, where, from a feeble peristalsis and from debility of the muscular apparatus at the lower end of the bowel, there is not sufficient power to dislodge the accumulations. I have seen much suffering result from the practitioner's failure to appreciate the true condition of a patient with these symptoms.

When the impaction is higher up, that is, above the rectum, the hardened mass of fæces may be discovered by the fingers through the abdominal walls, provided the person be not too obese.

When a person seized with obstruction has for a long time suffered from dyspeptic symptoms, with torpid bowels; when there have been alternations of constipation and diarrhœa, with an occasional discharge of blood; when there has been a steady loss of flesh and strength, with a cachectic impress upon the face; and when, as not unfrequently occurs, a stercoraceous abscess opens into the bladder or the vagina, or upon the surface of the abdomen, the existence of cancer may be affirmed with great certainty. Often in these malignant depositions the tumor or induration can be felt through the parietes of the body.

Stricture of the bowel, when beyond the reach of the finger, may be con-

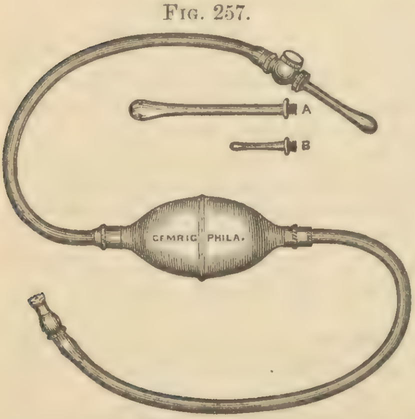
jectured from the resistance offered to injections, or when the latter are immediately and forcibly rejected from the bowel.

When the obstruction arises from tumors, the existence of the latter can generally be discovered by an examination through the abdominal walls or through those of the vagina or rectum.

TREATMENT.—In the treatment of intestinal obstruction, the most rigid analysis should be instituted in order to ascertain as nearly as possible its cause. All the hernial regions should be carefully examined, in search of a rupture. I have seen a number of fatal cases of obstruction in which this cause had, unfortunately, been overlooked. Much evil is often done by the irrational practice of indiscriminately administering active cathartics. It is from this cause that a fatal peritonitis is often engrafted upon the intestinal block.

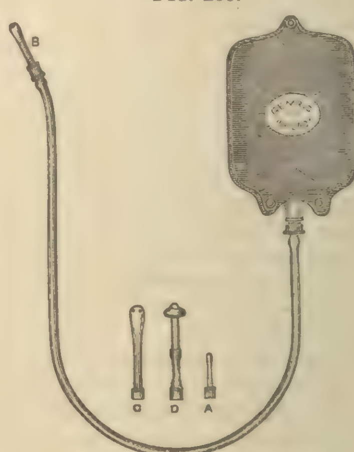
When there is reason to believe that the case is one of impaction of the great cul-de-sac of the rectum, the finger should be well oiled, introduced into the bowel, and the principal feculent masses broken up and removed. This method is to be preferred before any of the instruments recommended for this purpose. After the collection is in a good measure dislodged, the remainder can be washed out by large enemata of sweet oil and flaxseed mucilage, or by soap-and-water. I have never derived much benefit from the solvent power of ox-gall, so often recommended as an injection in these cases of impaction. When the accumulation is at the upper part of the colon, and the mass can be felt through the walls of the abdomen, it may be first broken down by pressure before exciting the peristalsis of the bowel for its removal. I succeeded in this way in starting an obstinate fæcal obstruction which resisted the ordinary measures employed for its dislodgment. After breaking the fæcal mass, the action of the intestine should be solicited by large injections of flaxseed-tea, turpentine, and oil. To obtain the full benefit of an enema, it should be thrown into the bowel very slowly with a Davidson syringe (Fig. 257), so as not to provoke a premature expulsion. The bowel must be coaxed.

FIG. 257.



Davidson syringe.

FIG. 258.



Hydrostatic injection apparatus.

The hydrostatic plan of administering an enema is to be preferred in such cases. It consists in pouring the fluid to be introduced into the bowel into a rubber bag having a long, flexible tube with a nozzle at its end. (Fig. 258.) The pressure can be regulated with great gentleness and uniformity by raising the bag to any required height. By injecting a large quantity of warm water containing a little salt, we may hope to overcome and successfully relieve fæcal obstructions, whether depending upon inertia of the bowel or upon an incomplete stricture. As a medium for conveying an injection into the bowel,

a long gum rectal tube may be introduced, carrying it as high up as possible, and throwing the fluid through its cavity. When a stricture exists within reach of the finger, the latter should be used to pilot the tube through, taking care not to perforate the bowel, the structure of which is often rendered weak by disease. Should these measures prove insufficient, we may next resort to the use of those remedies which not only act as laxatives, but which will also remove muscular spasm and pain. The combination which has been most successful in my hands is that of calomel, extract of belladonna, and opium:

℞ Hydrargyri Chloridi Mitis, gr. xii;
Ext. Belladonnæ, gr. iii;
Pulv. Rhei, gr. iii;
Pulv. Opii, gr. ii.
M.—Ft. pilulæ no. xxiv.
Sig.—One pill every two or three hours.

As an auxiliary to this remedy, an enema of flaxseed-tea, salt-and-water, or sweet oil, should be thrown into the bowel every six or eight hours. Whatever the injection may be, it is important that as large a quantity should be employed as the intestine will tolerate without creating too great distress. I believe injury is often done by too large injections. The value of large enemata consists in the expansion which they cause of the walls of the gut, and the possible consequent unwinding of a twist or the reduction of an invagination.

When the tympany is very great, relief will be experienced by tapping the intestine with a fine trocar. In two instances in which I had occasion to resort to puncture, the comfort, though not of long duration, was very marked for a time. The instrument which I employed for the purpose was the ordinary hypodermic needle. Farmers often practice this operation on their cattle, when the intestines become inordinately distended with gas from eating freely of green clover.

However obstinate a case may be, the surgeon should not relax his efforts to obtain relief. In a case of intestinal obstruction from inflammatory stricture, which I attended with Dr. Moffat, of this city, the difficulty was not overcome until after the lapse of forty-eight days. This patient died some time afterwards from what seemed to be marasmus. The large intestine was found sufficiently dilated to hold three gallons of water, the stricture being at the sigmoid flexure of the colon. In a second case, the patient was relieved after a period of thirty-five days from the commencement of her attack.

When the obstruction is supposed to be due to intussusception, opium will be required to relieve pain and quiet the peristalsis of the intestine. The injection of air into the bowel until it is well distended has been recommended. Mr. Erichsen believes he succeeded in this way in curing two cases of invagination. The operation can be effected by fitting the nozzle of a bellows to a flexible tube, at the end of which is attached a rectal pipe with a stop-cock; or the air may be pumped into the bowel with an ordinary stomach-pump.

A spontaneous cure of intussusception has frequently occurred by the invaginated portion sloughing away and being discharged from the rectum. In one case, eighteen inches of intestine were discharged through the anus;* in another case, recorded by Bush,† fifteen inches of the ileum were passed. Van Buren reported one case in which five feet of the bowel were discharged, followed by recovery; and a similar instance is given by Peaslee. Professor Gross‡ also speaks of having had presented to him, by the late Professor Dawson, a portion of the colon twenty-nine inches in length which had been passed by a child six years old.

In 11 out of 20 cases recorded by Mr. Hinton, 9 recovered; in 59 cases collected by Haven, mortification occurred 12 times, with 10 recoveries; in

* Duncan's Commentaries, vol. ix. p. 278. † Medical and Physical Journal, 1823.
‡ Gross, Surgery, vol. ii. p. 675.

50 cases collected by Dr. J. L. Smith, of New York, 7 recovered; Duchaussoy has gathered from various sources 135 cases, with 29 recoveries; making an aggregate of 259 cases, with 55 recoveries.

When the usual measures for the reduction of the intussusception have failed, and there is reason to believe that the vitality of the parts is not lost, it will be proper to open the abdomen and disengage the invaginated portion of the bowel. Hemorrhage is said to contra-indicate a resort to operative measures, as it indicates the commencement of sloughing; but others interpret this symptom as only an evidence of intense congestion.

Operation.—An incision should be made in the linea alba, below the umbilicus, dividing the layers carefully on the director. After opening the abdomen, a finger should be introduced into its cavity and the seat of obstruction sought for with as much gentleness as possible. When discovered, it will be necessary to introduce the fingers of both hands, so as to pull the upper and lower portions of the invaginated bowel in opposite directions. In a child—under the care of Dr. Potter—on whom I operated for intussusception of the large intestine, I found it necessary to exercise this mode of traction. Mr. Hutchinson thinks it better to draw the sheath of the invagination downwards. If the upper part alone be pulled upon, the bowel becomes so narrowed by elongation as to constrict more tightly the included portion. Marsh operated successfully for invagination in an infant seven months old, and Fagge reports a like result in the case of an adult.*

If the obstruction depend upon narrowing of the intestinal tube from carcinoma, and the growth occupy the rectum or the descending or transverse colon, a resort to operative measures may be required, with a view to establish an artificial anus; and when there is a complete blockade from malignant disease continuing for days, with tympany, pain, and inability to retain food, colotomy should be executed without delay. The relief from horrid suffering, even if life is only prolonged for a few months by the operation, will amply compensate the patient for submitting to the inconvenience of an artificial anus.

When the obstruction is due to strangulation, all remedies except opium are useless; and when the impediment to the passage of the fæces is complete, with stercoraceous vomiting, there remains, as the only avenue of escape from death, the operation of *laparotomy* or enterotomy, though, unfortunately, this measure offers but a gloomy prospect of relief. The difficulties which confront the surgeon in these cases are of such a nature that he does not feel at liberty to urge the use of the knife. These are the recognized uncertainty of the diagnosis, the presence of peritonitis, and the exhausted state of the patient when the operation is seriously contemplated. Should the obstruction be due to impacted calculi, or, as I saw in one instance, to a compact ball of straw, an operation will be attended with great risk, as the removal of the cause requires that the intestine be opened, a procedure which adds the most dangerous complication to the case.

A very important factor in the mortality following the opening of the abdomen is the handling to which the intestines are subjected in seeking for the seat of obstruction. Mr. Maunder, recognizing this fact, in a case where the cause of the difficulty was higher than the colon, cut directly down upon a distended coil of intestine, puncturing the tube in order to allow the imprisoned air to escape, and then drew the intestine through the incision in the parietes, and, after enlarging the opening in its walls, stitched it to the external wound, thus forming successfully an artificial anus.† Mr. McCarthy‡ by the same method succeeded in saving the life of a patient suffering from obstruction located in the small intestine. In neither of these cases was the nutrition of the individual seriously impaired by the artificial anus, although it was situated so high in the alimentary canal.

Colotomy.—In performing colotomy, the colon has been approached in dif-

* British Medical Journal, January 1, 1876. † Ibid., April 1, 1876. ‡ Ibid.

ferent ways. Littré, who was the first to suggest the operation, as early as 1710, recommended reaching the sigmoid flexure through the left iliac region, but it was not until sixty-six years afterwards that the suggestion was put into execution, on the right side, by Pillore, who cut into the cæcum through the right iliac region and stitched the bowel to the wound in the parietes. The operation was undertaken in consequence of the presence of a malignant mass in the rectum. Twenty-one years later,—1797,—Fine opened successfully the transverse colon, through the umbilical region, for cancer of the rectum. The previous year, Callisen advocated the left lumbar region as the best route to the intestine, and the sigmoid flexure as the proper portion to be opened.

Colotomy is most successful when the obstruction is situated in the rectum or in the sigmoid flexure, as it enables the surgeon to select for his operation the descending portion of the intestine, which is the most fixed, and which offers the largest non-peritoneal surface. The method usually pursued is a modification of Callisen's, and is known as that of Amussat, a French surgeon who applied it to the ascending colon. In its performance the left lumbar region is selected. Three incisions have been recommended,—a vertical one by Callisen, a transverse one by Amussat, and, more recently, an oblique one by Bryant. That of Amussat or of Bryant is to be preferred, and is equally well adapted for left or right lumbar colotomy. The chief advantages of the transverse or oblique incision over the vertical are a more capacious and gaping wound, the division of fewer lumbar arteries, and an easier recognition of the structures to be divided.

Left lumbar colotomy.—In order that the loin be made as prominent as possible, the patient should be laid on the right side, over a pillow rolled into a cylinder, the body being turned somewhat upon the face and breast. A point one inch posterior to the middle of the crest of the ilium being ascertained, it should be marked with tincture of iodine or with ink, in order that it may be clearly distinguished by the surgeon during the different stages of the operation. The colon will be found exactly in a line with this mark. An oblique incision is next made through the integuments, five inches long, midway between the crest of the ilium and the last rib, commencing over the erector spinæ muscles, about one inch and three-quarters external to the spine, and terminating one inch above and posterior to the anterior superior spinous process of the ilium. The different strata of muscles and the lumbar aponeurosis are to be consecutively divided on the director, all vessels being secured as the operation proceeds.

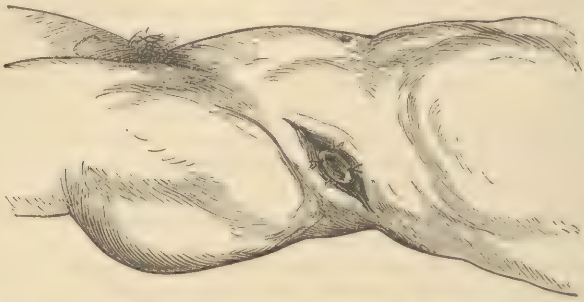
The fascial origin of the transversalis muscle, being reached, must be opened, when the external margin of the quadratus lumborum will be seen, and will perhaps rise up into the wound. Search should now be made for the colon. In some cases the kidney is so low as to require being pushed aside that the intestine may be found. In a patient operated on by Dr. Morton, in the Pennsylvania Hospital, a large renal cyst so concealed the colon as to require tapping before the bowel could be reached. If the loose fatty tissue in the lumbar region be displaced, the intestine will be found one inch posterior to the middle of the crest of the ilium.

In making this search, the surgeon must be careful to work backwards, under the quadratus lumborum muscle. If the exploration be carried forward, there will be great danger of opening the peritoneum. To identify the intestine, the operator should examine for the circular constrictions or the longitudinal bands which distinguish this part of the tube. Frequently the fæces can be felt through its walls. It has been suggested by certain writers to distend the bowel by injecting a fluid into the rectum, so that its position may be more readily recognized. The objection to this procedure is the probability that a part of the liquid will escape into the cellular tissue of the lumbar region when the gut is opened. Sometimes the intestine presents at the wound the moment that the transversalis origin of the lumbar aponeurosis is divided. Should this not follow, I find that

a strong pressure of the hand against the outside of the lumbar region will serve to produce the required protrusion.

When the bowel is found, it should be drawn forward by the fingers, so as to expose its posterior surface, and two ligatures passed through its walls, three-quarters of an inch from each other, in a direction corresponding to the longitudinal axis of the tube. These threads must next be committed to an assistant, who is to retain the intestine forward in the external wound while the surgeon makes an opening into the gut, three-quarters of an inch in length, from above downwards, and between the sutures. Through this incision the ligatures are to be drawn out, and divided in the centre, making four sutures out of the two, by which sutures the intestine is to be stitched to the sides of the external wound, including only its integument. (Fig. 259.)

FIG. 259.



Showing the extent and direction of the incision in left lumbar colotomy, and the intestine opened and attached to the integument.

I find it necessary to introduce two additional sutures, so as to command the entire circumference of the intestinal opening. The wound in the abdominal wall should next be united by silver wire close up to the bowel. In the course of three or four days, union between the parts will have been measurably effected, and in four or five more the stitches can be removed. Should there be no discharge of fæces at the time of operation, it is well: a little delay in this particular will give time for the adhesion of the parts and render the escape of the intestinal contents into the cellular tissue of the loin less probable. The wound should be dressed with carbolic acid and olive oil, and covered with a soft cushion of oakum, the loins being surrounded with a broad piece of muslin. When cicatrization has been completed, it will be necessary for the patient to wear a pad to guard the artificial anus and prevent the continued flow of feculent matter. The most satisfactory appliance is a hard-rubber truss with a large pad, one of its surfaces being heated and depressed so as to form a cup, which, when placed over the opening, can be retained by the spring moulded to conform to the surface of the body.

The operation on the right side does not differ from that on the left, except in the cæcum being opened instead of the descending colon. The fact that by this operation the large intestine can be reached without opening the abdominal cavity or disturbing the peritoneum makes it a much more desirable method than that of Littré, in which the sigmoid flexure or the cæcum was approached in front, and by which both the parietal and the visceral layer of the peritoneum were wounded. The result in quite a large number of cases exhibits the superiority of Amussat's method over all others. Of 17 patients in whom Littré's operation was performed, 10 died; while in 31 in whom the bowel was opened after the Amussat plan, there were but 14 deaths.

As early as March, 1838, Dr. William Ashmead, of this city, opened the left colon by a vertical incision in the triangular space between the latissimus dorsi and external oblique muscles. In 1847, Professor J. M. Bush performed

colotomy for a cancerous stricture of the sigmoid flexure of the colon, the patient living fourteen days after the operation. This, sometimes stated to be the first colotomy in this country, was nine years after that of Dr. Ashmead. Dr. Packard,* in 1875, opened the left colon in consequence of an obstruction of the rectum from cancer of the uterus. The patient lived eight and a half months. After the artificial anus was established, the fæcal discharges were passed through the opening with singular regularity every twenty-four or forty-eight hours, and no unpleasant odor was noticed about the patient. These facts I have myself observed, and they accord with the experience of other operators.

The general result of colotomy operations may be gathered from the tables of those who have given the subject a very careful and patient examination.

Cæsar Hawkins† collected and analyzed 44 cases of colotomy; being a record of all cases which he could find up to the year 1853. Of this number 23 recovered and 21 died. The operation was done 15 times for stricture of the rectum and of the sigmoid flexure of the colon, thought to be of a non-malignant nature; 3 times for non-malignant stricture of the ascending and transverse colon; in 1 case for a twist in the ascending colon; in 1 case for adhesion of the rectum to the uterus; in 1 case for a strangulation of the ileum by a band; in 1 case for fistula in ano; in 1 case for agglutination of the rectum to the uterus from cancer; 15 times for malignant disease of the rectum and of the sigmoid flexure of the colon; in 1 case for cancer of the colon and omentum; in 1 case for cancerous stricture of the cæcum; and in 4 cases for causes unknown. This collection included persons of all ages, from twenty-one to seventy years,—22 of which number were females and 21 males; sex of one not ascertained. Taking up the subject at the period where Mr. Hawkins stopped in 1853, Dr. Erskine Mason‡ has collected 80 cases of colotomy down to 1873. In 74 of these the descending and in 2 the ascending colon was opened by Amussat's method. In 1 case the bowel was opened after Callisen's plan. Three of the cases were operations on the small intestines. The result, as far as could be ascertained, was 54 recoveries and 23 deaths. The shortest period of survival after the operation was sixteen hours, the longest six years. It was ascertained that the peritoneum was wounded 7 times, in consequence of which 4 died. If we add together the cases of Hawkins and Mason, with 1 by Dr. Ross, of Montreal,§ 1 by Thomas,‖ 1 by Packard, 1 by Morton, and 1 by myself, we have a total of 129 cases, with 81 recoveries and 48 deaths,—a highly favorable result indeed. Even when performed solely with a view to mitigate suffering, the patient is amply compensated in the comparative exemption from pain which follows, and for this reason alone the surgeon ought not to withhold from the sufferer the only means at his command to make what remains of life endurable. In those diseases not necessarily fatal for which colotomy is performed, the question naturally arises, Can the artificial anus be closed after the recovery of the patient, and when the necessity for its presence no longer exists? Thus far I am not aware of any successful closure of such an opening, though it has been tried by Allingham, Bryant, and others.

Obstruction, when of an acute nature, from strangulation, twist, bands, entanglement, or from hernia reduced in mass, etc., is a formidable affection, and, unless relieved by an operation, dooms the patient to certain death.

Of 33 cases of acute obstruction from various causes, collected by Adelmann, in which the abdominal section was made, 15 recovered and 18 died. The particular conditions demanding the operation were: for twist 4 times, of which number 2 died and 2 recovered; for hernial strangulation after reduction 7, of whom 5 recovered and 2 died; for intussusception 5, with 2 recov-

* American Journal of the Medical Sciences, Jan. 1875.

† Transactions Royal Med. and Chirurg. Society, London, vol. xxxv.

‡ American Journal of the Medical Sciences, Oct. 1873.

§ Canada Med. and Surg. Journal.

‖ Thomas, Edinburgh Med. Journ., Sept. 1869, p. 262.

eries and 3 deaths; for foreign substances in the intestine 3, with 2 recoveries and 1 death; for prolapse of a portion of the small intestine through a rupture in the walls of the rectum 2, both of whom died; for strangulation from bands 8, with 2 recoveries and 6 deaths; for tumors and for hypertrophy 4, with 2 recoveries and 2 deaths.

Dr. Fagge, in an article on intestinal obstruction,* says that of 75 cases treated at Guy's Hospital during a period of fifteen years, 17 were from bands. Dr. Brinton, in his work upon the same subject, states that in 600 cases 31 per cent. were from bands; 43 from intussusception; 17 from stricture; and 8 from torsion. The small intestine was the part of the canal affected in 95 per cent. of the cases originating from bands. When from stricture or twist, 88 per cent. of the cases were found to involve the large intestine.

Dr. Ashhurst, in a very interesting and carefully-prepared paper on laparotomy,† has collected the history of 13 cases in which abdominal section was made for the relief of intussusception, 8 of which number died and 5 recovered. Of these 13 cases, 4 were children under one year of age, all of whom died. The fatality of invagination, with or without operation, in very young children, has been remarked by every writer of prominence upon the subject. The table of Dr. Ashhurst shows that when the signs of severe strangulation are present (namely, hemorrhage and peritonitis) an operation is contra-indicated; a fact which, as the author of the paper remarks, is corroborated by Hutchinson and Leichtenstern. There are cases in which recovery takes place by the strangulated portion sloughing away. In 557 cases analyzed by the last-named author, where the result was ascertained, sloughing occurred in 149, of which number 88 recovered and 61 died; while of the remaining number, 408, in which sloughing did not take place, only 63 ended favorably, and 345 died, a mortality of 85 per cent. It would appear from these results that abdominal section for invagination, during the first year of infantile life, holds out no promise of success. This would exclude a very large number of cases from operative interference, as 91 of the 162 cases collected by Peltz were children under a year old. If, in addition, all those cases of intussusception, whether in children or adults, in which acute strangulation exists (indicated by hemorrhage and peritonitis), be deemed unsuited for the knife, we have the operation confined to a very limited number of cases,—that is, to persons over one year old, and in whom the symptoms are not acute,—and in these only after the ordinary remedies have been used and have failed. After a very careful study of the subject from all the sources of information at my command, I believe this deduction to be sound.

Dr. Ashhurst has also brought together 57 cases of laparotomy for acute intestinal obstruction from causes other than invagination, 18 of which recovered and 39 died, a mortality of 68 per cent. The most common causes for the obstruction he found to be as follows: from bands, 13 cases, of which number 10 died and 3 recovered; from persistent strangulation after the reduction of hernia, 10 cases, 5 of whom recovered and 5 died; from volvulus or twist, 9 cases, 3 of whom recovered and 6 died; from strangulation by omentum, by mesentery, by a diverticulum, from old adhesions, and from hernia, 9 cases, 3 of whom recovered and 5 died, one not being determined. In the remaining 16 cases the causes for the obstruction were cancer, and foreign bodies impacted in the bowel. It will be observed that of the entire number, 41 cases were of obstruction caused by strangulation in some form or other. This is in harmony with the observations of Drs. Fagge and Brinton, and a condition which, from its frequency, will aid the surgeon somewhat in removing cases of this nature from the region of mere conjecture and render his diagnosis more certain.

Intestinal obstruction from any of the causes above enumerated, without operation, is almost invariably fatal; and therefore, after persevering for sev-

* Guy's Hospital Reports, 1868.

† American Journal of the Medical Sciences, July, 1874.

eral days in the use of the usual remedies without effect, or until the patient begins to exhibit symptoms of failing strength, it will be proper to resort to the knife. In acute cases it is better not to delay operative measures too long.

Abdominal Section, or Laparotomy.—In opening the abdomen through the peritoneum for the purpose of relieving strangulation, the patient should be placed in the recumbent position and the bladder emptied of urine. An incision should next be made in the median line, beginning half an inch below the umbilicus, and carried down three or four inches towards the pubes. By successive strokes of the knife, the skin, subcutaneous tissue, and anterior abdominal aponeurosis are to be divided, the recti muscles separated the entire length of the external wound, and an opening made through the fascia transversalis and peritoneum sufficiently large to admit the passage of the finger, which will serve as a director for the further enlargement of the wound. Search should now be made for the seat of the strangulation, by following downwards any coil of intestine which may be seen to be distended with gas, and, when the obstruction is discovered, the involved portion of the tube should be divided, torn, untwisted, or liberated, as the case may be. If there be found an impaction by foreign substances, the intestine should be brought through the external wound, opened, and the offending mass extracted, after which the bowel should be stitched to the opening in the parietes by a number of interrupted sutures, the greatest care being exercised that no extravasation of fæces into the peritoneal cavity takes place. Some, instead of adhering to the linea alba, have advised cutting directly upon the bowel wherever it is found distended, bringing it into the incision thus made in the parietes of the abdomen, and, after opening the tube, attaching it by sutures to the external wound. When it is desirable to establish an artificial anus, and when the site is not impracticable, the inguinal region should be selected for the accomplishment of this purpose, as the least objectionable position both as regards cleanliness and the application of a mechanical appliance to control the orifice.

After the operation of abdominal section, the wound, with the exception of the part to which the intestine is sutured, must be closed by silver wire, and the patient be kept quiet upon the back, with the shoulders raised to relax the parietes. Opium will be required in sufficient quantities to secure relief from restlessness and pain, and especially to preserve peristaltic rest. This treatment should be kept up for a period of ten or fourteen days, when the dose may be diminished, and in the course of two or three days more it may be entirely suspended, after which it may be necessary to open the bowels by an injection or by some gentle laxative, should they not act spontaneously. The diet best suited to such a case is milk and beef-essence, which should be given in small quantities and repeated every hour or two.

Diseases of the Anus and Rectum.

General Observations.—In the investigation of diseases of the anus and the rectum, there are several points connected with the examination of patients which demand consideration.

First. Position for examination.—In females, the position which I prefer is that on the side or partly on the breast, with the limbs well drawn up towards the abdomen and the hips near to the edge of the bed. When the patient is a male, the best posture is that upon the elbows and the knees, the head and shoulders being low, and the hips well elevated and placed opposite a good light. In this position the viscera gravitate towards the chest, and when the proper speculum is introduced, the air expands the bowel to a degree which admits of the most satisfactory examination. If the object is to examine the interior of the anus, a towel or a napkin interposed between the fingers and the integument will enable the surgeon to unroll or evert the mucous surface, if at the same time the other buttock be drawn in the oppo-

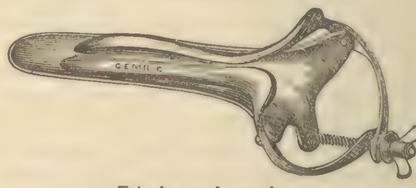
site direction by one hand of the patient or by that of an assistant. If it is desirable to enter the bowel with the finger, the nail should be well shielded by scraping it a few times over a piece of moist soap, which will fill up the space underneath. By a digital examination we may ascertain the existence of hemorrhoids, stricture, the presence of morbid growths, foreign bodies, and fæcal accumulations.

In the female we can evert the lower end of the rectum very satisfactorily by inserting a finger into the vagina and pressing upon the recto-vaginal septum. The introduction of the hand and arm into the bowel has recently been practiced by Simon and others, with a view to explore the colon and other parts within the abdomen. The benefits resulting from such violence are of so doubtful a character, and the evils which have resulted are so serious, that I feel compelled to condemn the practice as rash and revolting.

Fig. 260.

Bivalve anal speculum.

Fig. 261.

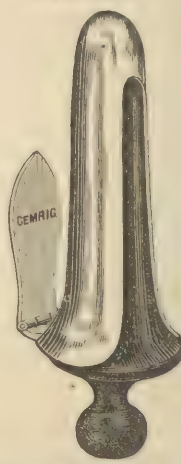


Trivalve anal speculum

Fig. 262.

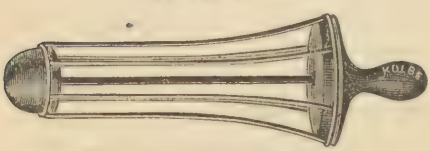
Anal speculum with an oval opening on the side.

Fig. 263.



Anal speculum with an elongated fenestra and with stylet.

Fig. 264.



Wire anal speculum with stylet.

The instrumental exploration of the rectum is accomplished by different kinds of specula. The ordinary forms of anal specula are the bivalve (Fig. 260), the trivalve (Fig. 261), the cylindrical, of which there are two kinds, one having an oval opening on its side (Fig. 262) and the other an elongated fenestra and stylet (Fig. 263); also the fenestrated wire speculum with stylet (Fig. 264).

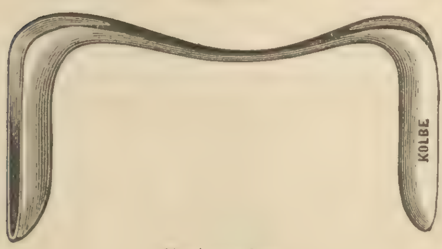
The bivalve, trivalve, and wire specula are constructed of metal, and the cylindrical ones are made of glass or of hard rubber, the inner surface of the tube being highly polished, so as to prove a good reflector of light. The instrument which in a large majority of cases I prefer is the ordinary Sims' speculum. (Fig. 265.)

To cleanse the mucous membrane of the bowel, a piece of soft sponge or a pledget of lint and a pair of dressing-forceps will be required.

A very thorough exposure of the rectum, to the extent of three inches, may be obtained by etherizing the patient and using the two index fingers as one would employ a bivalve speculum, thus forcibly dilating the sphincters. Preliminary to an examination of the rectum, it is often necessary to clear the bowel of all fæcal accumulations by means of an injection: indeed, in obscure cases of rectal disease, no examination is complete without this preparatory measure. Enemata may be prepared from different materials. Those in common use are plain water, cold or warm; water, with the addition of a tablespoonful of salt or of some Castile soap; flaxseed-tea, sometimes with the addition of the spirits of turpentine; castor or sweet oil, with molasses and lard; starch suspended in water; with many others of less value.

When clysters are administered, the patient should be placed on the side near to the edge of the bed, with the knees drawn up. When a small enema is required, one, for example, not exceeding two or three ounces, the best instrument for the purpose is a hard-rubber syringe, holding about four ounces (Fig. 266); and if the nozzle be curved, the patient will be able to

Fig. 265.



Sims' speculum.

Fig. 266.

Hard-rubber syringe.

use it without assistance, especially when in the standing position. When larger injections are required, the best instrument for the purpose is the Davidson syringe, (Fig. 257.)

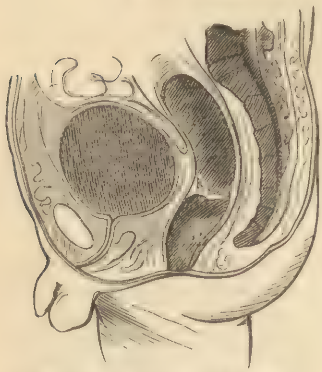
The metal or hard-rubber nozzle in all clyster syringes should be discarded and bone used instead, the extremity being blunt and smoothly rounded. Whether bone or metal be employed, great comfort and safety will be realized by slipping over the nozzle a rubber shield. The softness and flexibility of the gum admit of its being introduced into the bowel without the least inconvenience or pain. The point of the nozzle, after being smeared with lard, cold cream, or zinc ointment, and all air expelled from the syringe, should be inserted into the anus and directed upwards and backwards towards the sacrum, so as to keep the instrument in the axis of the bowel until both sphincters are passed, when the contents of the instrument should be slowly discharged into the rectum. When it is desirable to retain an injection permanently, the quantity must be small, and the patient should maintain for fifteen or twenty minutes the recumbent position after its reception.

Congenital Malformation of the Anus and Rectum.—Such anomalies in development are not of rare occurrence, and are, unfortunately, in most cases not correctible by surgical operations.

Malformations of the anus are of three kinds: *first*, preternatural narrowing

of the anal aperture; *second*, cutaneous or membranous occlusion (Fig. 267); and, *third*, entire absence. An additional complication may exist in conjunction with any of these varieties,—namely, that of a fæcal fistula,—which may communicate with the vagina, the bladder, the urethra, or may open upon the surface of the body, near to or remote from the perineum. These defective conformations of the anus and of the rectum, according to Curling, are more common to males than to females. In 90 cases, 68 were males and 32 females. This difference in favor of male children is not sustained by the tables of M. Bouisson. Of the 100 cases tabulated by this author, 53 were females and 47 males. In my own experience, the masculine sex has been much oftener the subject of this vice of development than the feminine.

FIG. 267.



Membranous occlusion of the anus.

In the first variety, or that where the anal orifice is preternaturally small, the opening is not always in the normal position. In a case which I saw with Dr. Henry S. Gross, of this city, it was situated at the anterior extremity of the raphé of the scrotum, or where the latter joins the penis, and it received with difficulty the point of a small silver probe. In these cases of simple anal malformation there will be more or less bulging of the parts by the descent of the meconium when the child cries or strains. If the anus is absent, this protrusion or conical extension of the perineum will not be present, but the finger pressed against the anal region may detect an impulse from the pressure of the intestinal contents which the eye cannot discern. These are the forms of anal malformation which admit of treatment.

When the orifice in the gut is contracted, or when the occlusion consists of a thin membrane, the proper plan is to make a crucial incision, and to instruct the nurse or the mother to introduce, daily, a bougie, made by melting or shaving a tallow candle down to the proper size. When the anal orifice opens some distance from the proper place, it should be slit up to the bowel upon a director, after the manner of dividing a fistula.

In cases of entire absence of the anus, a careful dissection will be required in the direction of the raphé, through the skin, muscular and cellulo-adipose structures, taking care to follow the slight curve of the coccyx and sacrum, and using from time to time an exploring-needle, in order to detect the presence of the meconium and thus have a guide for the safe progress of the incision. If the rectum is successfully reached and opened, it is necessary to bring it down and to attach its mucous membrane, by means of interrupted sutures, to the margin of the external wound, after the manner of Amussat, in order to prevent the cicatricial contraction of the newly-formed anus. In these cases of imperfection and of absence of the anus, the external sphincter is generally present, though it may not be complete in all respects. Its entire absence, however, would not entail fæcal incontinence, as the office of guarding the lower end of the gut against involuntary discharges belongs to the internal sphincter. A very unfavorable complication of imperforate anus is that of fæcal fistula.

The most common malformations of the rectum are the following: *first*, partial absence,—that is, the bowel ending at various distances from the anus (Fig. 268); *second*, entire absence; and, *third*, abnormal termination in the vagina (Fig. 269), bladder, urethra, or other unusual position. These vicious conformations of the rectum may be associated with a perfect anus, or with any of its imperforate forms.

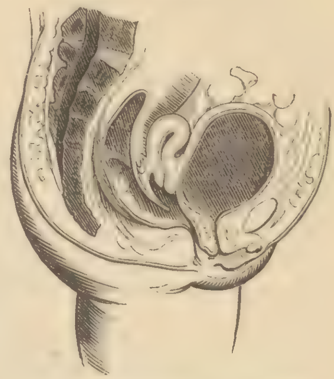
It is only when the rectum terminates a short distance from the surface that the meconial tumor can be felt. It may protrude into the anus, when

the latter is present, or it may be detected by inserting a finger into the anal orifice. Unless the surgeon is able to see or to feel this distention pro-

Fig. 268.

Rectum terminating at the top of the sacrum.

Fig. 269.



Rectum terminating in the vagina.

duced by the imprisoned contents of the intestine, any opinion as to the termination of the rectum can only be mere conjecture.

When there is associated with an imperfection of the bowel an imperfectly-developed pelvis, the lower diameters being much contracted, the entire absence of the rectum, on the authority of Rokitansky and Curling, may be assumed. It is alleged that if a catheter or sound, introduced into the bladder or vagina, is found to strike directly in contact with the sacrum, it indicates the absence of the rectum. The sensations imparted by this test are not, however, by any means decisive on this point.

When the abnormal condition of either anus or rectum is such that no escape of the intestinal contents can take place, the child soon loses its appetite, cries, and refuses its nourishment; the abdomen becomes distended, vomiting follows, and the little sufferer sinks and dies, as in ordinary obstruction of the bowels. That a child may survive for a long time with such a malformation is attested by the case related by Bodenheimer, in which a child with absence of the rectum was not operated upon for three months after birth, and yet enjoyed perfect health. The intestine was found three inches from the surface, and the child was known to be alive two years after the operation, quite well, and with perfect control over the bowel.

Treatment.—In cases where the anus exists, and the rectum terminates low down in a membranous cul-de-sac which is likely to be distended by the straining efforts of the child, a grooved needle should be first introduced into the swelling, in order to ascertain its contents, and, if they are found to consist of meconium, a puncture should be made with the point of a knife sufficiently large to admit the blade of a blunt-pointed bistoury, with which the wound may be freely enlarged. When the rectum ends higher up, and is associated with absence or imperforation of the anus, exploratory punctures are hazardous, especially when made with an instrument the size of the ordinary trocar. It is impossible to determine how low the peritoneum descends, and these stabs in the dark may do great harm by wounding this membrane. The best plan to pursue is that of making a careful dissection, the child being etherized and held in the position of a patient about to be cut for stone. The incision should be made in the direction of the perineal raphé, over the place where the anus is normally situated, and be continued cautiously up, close to the coccyx and to the sacrum, guided by a finger in the anterior part of the wound. If the surgeon be fortunate enough to reach the gut and to make an opening into its cavity, he should endeavor to draw it down by the forceps and connect it by sutures as near the surface of the external wound as pos-

sible. The depth to which it is proper to go in search of the bowel has not been determined. Mr. Erichsen reached the rectum, in one case, at the distance of three inches from the surface, but the child subsequently died from pelvic cellulitis.

Curling places the limit of incisions at one inch and a half, and any one who carefully dissects the perineum of an infant will, I think, entirely agree with this writer. Beyond this depth, the cul-de-sac of the peritoneum will probably be laid open. Whenever, therefore, the search for the rectum at this distance proves fruitless, the operation of colotomy should be made, rather than to pursue farther a blind search in a dangerous region. In connection with this subject two questions arise: first, is the attempt to save the life of a child by the resort to an artificial anus advisable? and, second, if so, which is to be preferred, the lumbar or the inguinal operation?

To determine the first is a very simple piece of casuistry: it is always the duty of the surgeon to save life, and if he neglects to employ all the resources of his art to that end, he has failed to meet the moral requirements of his position.

In regard to the best method of reaching the colon in infants there is a difference of opinion. The objections urged against lumbar colotomy are the great depth of the descending colon; its mobility in consequence of the length of the mesocolon, rendering it difficult to find, or, when reached, exposing the peritoneum to injury in the act of opening the bowel; and, finally, the possible displacement of the colon, the gut being frequently situated on the right of the median line. A distended and resonant condition of the right iliac region, with a flat state of the left, will indicate to some extent this displaced position of the bowel. It is certainly much easier to reach the intestine by Littré's operation—that is, in the inguinal region—than by Amussat's plan, through the loin; but the former involves, of necessity, the opening of the peritoneum, which exposes the patient to the risk of peritonitis. The cases collected by Mr. Curling are not sufficiently numerous to justify any decided conclusions from a comparison of the two plans, though most favorable, as far as they go, to the operation in the groin.

In fourteen cases in which Littré's operation was performed, nine recovered, while in seven instances in which lumbar colotomy was done, only two proved successful. After examining the bodies of infants with reference to this point, the objections urged against the Amussat method of reaching the colon appear to me to be well made.

The great extent of the sigmoid flexure in new-born children, in consequence of which it is sometimes seen lying on the right iliac fossa, induced Huguier to insist that the operation should be done on that side; but this disposition of the bowel is by no means sufficiently common to warrant any such procedure. Mr. Erichsen, recognizing the difficulties which attend the opening through the loin, advises that the operation be done in the right lumbar region, thereby reaching the cæcum or the head of the colon.

The success which has followed colotomy in children for imperforation of the anus and the rectum cannot well be determined. M. Guersant* operated eleven times without a single success. A few cases of recovery are recorded by Vidal de Cassis, Rochard, Maisonneuve, and Amussat.

The operation of lumbar colotomy for imperforate anus or rectum in the infant does not materially differ from the same operation in the adult. If inguinal colotomy be preferred, the steps of the operation do not differ much from those for tying the iliac artery. An incision should be made over the left iliac region, parallel to and half an inch above Poupart's ligament, and extending from one inch external to the anterior superior spinous process of the ilium to a point opposite the middle of the groin. The skin being divided, the subcutaneous cellular tissue and the different tendinous and muscular layers should be raised and incised upon a director. When the peritoneum is reached and opened, the sigmoid flexure of the colon will probably

* Bull. de Thér., tom. xlix.

present at the wound. Two needles, each armed with a silk thread, should be passed through the walls of the intestine in a longitudinal direction. By these threads the bowel is to be drawn through the wound: it is then to be opened in its long axis, each margin being securely attached to the cutaneous edge of the parietal wound by a number of interrupted stitches.

Abnormal communications of the anus or rectum with adjoining organs constitute a serious complication:

First. The opening may exist between the anus and vagina, the rectum terminating some distance above. In such a case the anus should be divided posteriorly, and an incision cautiously carried upwards, following the sacrum. If the bowel be discovered, it must be opened, drawn down, and connected to the anus by sutures. In a case of this kind related by Amussat, the anus was entirely ignored, an opening being made between the latter and the coccyx, through which the rectum was reached and opened. This patient survived, grew up to womanhood, and was married.

Second. The rectum may terminate in the vagina, either with or without an anus. In either case the proper treatment consists in carrying a curved director into the vagina, and through the fistulous communication into the gut. The director should next be turned in such a manner as to press into the anus, or, in the absence of the latter, against the perineum, when a free incision should be made down upon its point, and be sufficiently enlarged to make a direct and ample way of escape for the meconium.

In a case of this kind which I operated on at the Pennsylvania Hospital the result was entirely successful. The fæces were gradually diverted from the vagina and the fistula closed up. There are a number of recorded cases of this imperfection, in which no effort was made to correct the infirmity, the presence of which does not appear to have shortened life or to have prevented pregnancy. When the opening between the bowel and the vagina is large, this operation may fail, in which case there remain two resorts: one of closing the recto-vaginal opening, by paring its edges and uniting them by sutures after the anal orifice is well established; and the other, by incising the perineum antero-posteriorly,—in the absence of the anus,—dissecting the rectum from the vagina, and, pulling it down, securing it by sutures to the external opening. This is the operation of Rizzoli, and resembles in many points that of Dieffenbach.

Third. The rectum may terminate in the bladder or in the urethra, and, as in those cases where the communication exists with the vagina, the condition does not involve any immediate risk to life, since the contents of the bowels can be discharged through these unnatural routes. Very commonly, however, sooner or later, the fistulous orifice becomes obstructed by the fæces as they begin to assume the solid form, or by foreign bodies, such as the seeds of fruit taken into the stomach. The certainty of such an obstruction is ample justification for making an attempt to reach the rectum by a cautious dissection through the perineum, detaching it from its connection with the bladder or the urethra, drawing it to the position of the new anus, and there connecting it by means of a number of interrupted stitches. Should the surgeon fail to discover the bowel, the operation of colotomy may be performed.

Fourth. The anus or rectum may open upon the surface at unusual localities; for example, on the raphé close to the scrotum, at the posterior commissure of the labia, and at other parts of the perineum. The treatment in such cases is to slit up the abnormal fistulous track, when near to the usual position of the bowel, and establish a free opening at the proper place for the normal anus. Larrey saw an infant seven months and a half old in whom the anus opened in the loin, three inches external to the spine.

Condylomata.—These formations are frequently seen scattered about the verge of the anus. They are sometimes called papillomata, at other times vegetations or warts. They appear as flat sessile elevations, having a granular, moist surface. These growths may be either distinct, or in patches closely

grouped together, and they emit a very unpleasant odor. They are composed of enlarged papillæ, or, what is the equivalent of these, of loops of blood-vessels, supported by connective tissue and covered with layers of epithelial cells. They grow exuberantly in a moist locality, a condition which generally exists about the anus, produced by the contact of the nates. They are supposed to arise frequently from carelessness in matters of personal cleanliness; but in most instances their presence can be traced to a syphilitic or gonorrhœal origin. They differ so widely in appearance from external hemorrhoids that, did I not know to the contrary, I should scarcely conceive it possible that the two diseases could be confounded with each other. External piles are either round, pendent tumors, or loose folds of the integument, having a smooth surface, whereas condylomata are flat, and possess an irregular, warty appearance.

Treatment.—The treatment consists in enforcing careful and frequent ablutions with carbolic acid soap and water, drying the parts thoroughly, and afterwards dusting with a powder consisting of equal parts of calomel and gallic acid, interposing between the folds of the buttocks a piece of old linen. The great object is to prevent the vegetations coming in contact, and to avoid the presence of moisture. Should this not answer, the growths should be clipped off on a level with the skin with a pair of scissors, and the bleeding surfaces touched with nitric or chromic acid. The hemorrhage which follows their removal is sometimes very profuse, and, should it not subside spontaneously, can be controlled by applying the powdered subsulphate of iron. When these warts return, the patient should be placed on a gentle mercurial course of treatment, never, however, carried to salivation. For this object the corrosive sublimate, in doses of one-thirtieth of a grain, will answer the purpose best.

Pruritus Ani.—Itching of the parts about the anus is most frequently the consequence of some disease or irritation within the bowel, such as piles, ulcers, worms, or parasites. In certain persons it is due to constipation, and in others appears to be connected with some peculiar state of the nerves of this region. A medical officer in the United States army, whom I treated for a distressing pruritus, informed me that the disease was very common in Mexico, and was produced by the same cause that had led to the affection from which he himself suffered, namely, the habitual use of a hot aromatic, a species of pepper. The leucorrhœal discharges of women often excite the disease by remaining in contact with the skin of the perineum and developing an eczema. The itching frequently occurs at night, after the patient retires to bed, and occasionally prevents sleep for hours. The sensations sometimes experienced are those of something crawling in the lower end of the bowel. When the irritation is severe, the disposition to scratch becomes irresistible, and the nails are often applied so vigorously as to cause excoriation and inflammation. The repetition of the scratching, and the prolonged irritation, so alter the skin that it loses its pliability, and becomes red, dry, and rough, or preternaturally white and scaly. A sea-captain who was a subject of pruritus ani told me once that when the itching came on, so intolerable was the distress, and so utterly was he at the mercy of his sensation, that all self-control was lost, and, though doing the honors of the table of his ship at the moment, and in the presence of ladies, he has involuntarily dropped the carving-knife and commenced vigorously to scratch his anus.

Treatment.—If there is reason to believe that the pruritus depends upon the presence of hemorrhoids, an operation for their removal will usually effect a cure. If it is caused by ascarides, they must be expelled by injections of carbolic acid and sweet oil (one part of the acid to six parts of oil). Enemata of turpentine and flaxseed-tea also answer a good purpose as a local anthelmintic, and the same is true of the dilute tincture of the sesquichloride of iron. If an ulcer exists in the bowel and causes the pruritus, little relief can be expected until it is healed by the application of caustics. Parasitic irritation is best relieved by injections of dilute sulphurous acid, or by sup-

positories of lac sulphuris. In some instances the disease is caused by constipation, or arises from causes connected with imperfect digestion: derangements of this kind must be corrected by a pill consisting of rhubarb, extract of belladonna, and extract of nux vomica. All stimulants and highly-seasoned food should be discarded. When the pruritus depends upon a disordered state of the nerves of the anus, independent of any local excitant,—a condition occasionally seen in delicate females,—the proper course will be to improve the general health by administering iron, quinine, and arsenic combined, directing local and general bathing and living as much as possible an out-door life. To relieve the itching, there are a number of local remedies which may be applied with advantage. Among these may be mentioned frequent ablutions with cold water, and the use of palm soap, from which a thick lather should be made and pressed into the anus with the finger. Mercurial and citrine ointments will often prove useful, and their efficacy will be enhanced by the addition of a little carbolic acid and morphia. Among the lotions which give relief are lead-water, camphor-water, and a solution of borax. The oxide of zinc ointment is best adapted to heal the excoriated surfaces. The nitrate of silver, of the strength of ten grains to one ounce of distilled water, is used for a similar purpose. When all other remedies have failed, I have used the following with the most gratifying result: sulphate of zinc and alum, equal parts, are to be placed in an earthen vessel and heated sufficiently to drive off their water of crystallization, or until they become a confluent, hard mass. From half a drachm to one drachm of this substance, powdered and dissolved in a little water, should be thrown into the rectum. In a few minutes it will destroy the itching. I have succeeded thus in curing cases of the disease which had for years defied all other remedies. The prescription, I believe, is an old English remedy. An injection which I have used with success when other remedies have failed is one consisting of thirty grains of the bromide of potash dissolved in half an ounce of cosmoline. A suppository containing three or four grains of iodoform, introduced into the rectum on retiring to bed, will be found to have an excellent effect in nocturnal pruritus. Allingham directs, for the same purpose, a metal or bone rectal plug, with two shoulders, to prevent its slipping into the intestine. This is to be introduced into the bowel at bedtime. The pressure which it exerts on the nerves and vessels of the parts effectually prevents the itching.

Sphincterismus.—This is a spasmodic contraction of the sphincter muscle of the anus. After it exists for some time the muscle becomes hypertrophied, and feels like a ring of iron. It is generally associated with spasm of the levator ani muscles, in consequence of which the orifice of the anus is so drawn up as to be scarcely visible. The patient in such cases often finds it difficult to expel the fæces, on account of the resistance offered by the strongly contracted muscle, and suffers considerable pain. I at one time believed that this state of the sphincter was always caused by the presence of a fissure or ulcer of the rectum, but I am now convinced that it may exist entirely independent of any such disease. It is not unfrequently the cause of fæcal accumulations in the rectum, which cannot be extruded without digital aid.

Treatment.—A careful examination of the anus and the rectum should precede all treatment, with a view to ascertain if there is any local disease which will explain the muscular spasm. If an ulcer is discovered, its treatment is of primary importance. When no structural alteration can be detected, and if the affection is associated with constipation, the bowels should be moved by gentle laxatives, like magnesia or rhubarb, and the diet regulated in such a manner as to exclude all highly-seasoned articles of food. Before retiring to bed, the patient will do well to take a hot hip-bath for twenty minutes, after which a suppository containing half a grain of the extract of belladonna may be introduced into the bowel. Should these means not prove successful, a bougie smeared with belladonna ointment may be passed through the anus daily, with a view to reduce the irritability of the

muscle. In obstinate cases, or such as do not yield to the gentle measures just described, it will be necessary to apply forcible dilatation. This is best done by etherizing the patient, introducing the index fingers into the bowel, and stretching the rebellious muscle until all resistance is overcome. If this proves unsuccessful, there remains, as a last resort, the division of the sphincter by the knife, as in cases of fissure. When the patient is pale and anæmic, and suffers from palpitation, flatulence, and sleeplessness, a course of iron, sea-bathing, and exercise in the open air, with a plain, nutritious, and unirritating diet, will form the best plan of treatment. Stimulants must be positively forbidden.

Loss of Co-ordination in the Muscles of Defecation.—The act of defecation is accomplished by the co-operation of the abdominal muscles and the diaphragm with the muscular walls of the rectum, the levatores ani, and the internal sphincter. In expelling the fæcal mass through the outlet of the gut, there are two very essential acts, namely, the consentaneous contraction of the walls of the rectum and the levatores ani, and the simultaneous dilatation of the sphincter. The effect of the first of these acts is to diminish the intestine both in its calibre and in its length, and to force the contents towards the anus. The effect of the second act is the opening of the lower orifice of the bowel, for the escape of the evacuation.

In a few instances I have met with cases in which the muscular co-ordination just alluded to, and which is necessary for the extrusion of the fæcal mass, was lost. The contents of the bowel would come down to the sphincter, and the latter would partially dilate, but that movement by which the lower extremity of the bowel is to some degree everted and elevated, and which is necessary to complete the final act, did not take place, rendering it necessary for the patient to dig the evacuation out of the intestine with the fingers. The defect appears to reside in the imperfect action of the longitudinal muscles of the rectum and of the levatores ani. This incapacity, though it may be caused by an injury to the lower end of the spinal cord, in which resides the centre directing the reflex movements concerned in defecation, is often connected with an impressible or a supersensitive state of the nervous system, closely allied to hysteria, and is consequently more frequently met with in females than in males. In the case of a lady, who came to Philadelphia to consult on account of this incompetency, I discovered a small erectile growth in the rectum, the extirpation of which very promptly removed the disability of the bowel.

Treatment.—A careful examination of the anus and the rectum should be made in search of polypi, ulceration, or any other disease possible to the locality; nor should the uterine or vesical organs be overlooked. If any structural alteration is discovered which would tend to cause this singular defect, it should be removed as far as practicable. If nothing of the kind can be found, the treatment must be directed to the improvement of the general system, comprising cold hip-baths, electro-galvanism, iron, and assafetida, with constant out-door exercise.

Fissure of the Anus.—Few affections of the bowel entail more suffering than anal fissure, sometimes called painful ulcer of the rectum. The position of a fissure is usually just within the verge of the anus, beginning at the cutaneo-mucous line and extending upwards towards the rectum for a distance rarely exceeding half an inch. It is a mere linear ulcer or crack in the mucous membrane of the anus, often so narrow that, unless the corrugation of the latter be unfolded, it will escape observation. Fissures may occupy any portion of the circumference of the anus, but in a majority of instances they will be found at its posterior or coccygeal side. They are occasionally multiple. Fissure is a disease of adult life, and is more common to women than to men. Nevertheless, very young children are not exempt from the affection. I have seen it in infants not over two months old.

Causes.—Fissure arises from a variety of causes, such as atony of the rectum, allowing the bowel to become impacted with hardened fæces, which, when discharged, overstretch the mucous membrane, thus either producing a direct lesion or provoking inflammation which results in the narrow ulcer. Chronic diarrhœa will induce the disease; also hemorrhoids and polypi. Sometimes it has a syphilitic origin, and at other times the cause will be found in a general derangement of the health.

Symptoms.—The most significant symptom of fissure is pain. This pain is of no ordinary kind. It is not generally experienced at the time of defecation, but sets in twenty minutes or half an hour after. At first a hot, throbbing sensation is experienced, which soon merges into a severe pain, and this continues to increase in severity until the suffering of the patient becomes agonizing. The behavior of persons during the paroxysm differs much in different cases. One will walk the floor like a madman; another will gradually settle into some position which to a spectator would appear very uncomfortable, but from which no entreaty could induce the sufferer to change. The sphincter ani will be found in a state of spasm, feeling to the finger like a ring of iron. After six or seven hours the suffering begins to abate, and gradually disappears, only to reappear, however, after the next evacuation from the bowels. In consequence of this, many dread the recurrence of the daily stool, and put it off or take some remedy to produce constipation.

To resolve all doubts, the anus should be examined. Let the patient be placed upon the side, with the limbs drawn up; raise the buttock, and with the fingers open the anus. If the mucous surface is not sufficiently exposed, an effort on the part of the patient like that put forth in defecation will accomplish this object, and if the disease is present a red linear ulcer will appear. When this is of long standing, the surface may be ash-colored and the margins indurated. Sometimes, instead of the ulcer being linear or elongated, it will be round or oval, in which case its situation will be somewhat higher in the bowel.

The effect of the prolonged repetition of such suffering as characterizes anal fissure is disastrous to the health of the patient. A female was brought to this city, believed to be a suitable subject for an insane asylum. She had become a profound melancholic. An examination revealed the existence of an anal fissure, the cure of which restored her to health both of body and of mind.

I once visited a young lady who had retired from society under the deepest mental despondency, and who had kept her room, a voluntary prisoner, for almost three years. It was with difficulty that she was persuaded to allow me an interview. After securing in some degree her confidence, and artfully drawing out some confessions, I suspected the existence of fissure, and verified it by an examination. When I told her that in a few minutes I could restore her to health and happiness, she believed that I was wantonly trifling with her sad condition. The operation was made, and a few weeks after a letter was received, replete with the most extravagant expressions of gratitude and joy.

A very curious instance of the reflex influence of anal fissure came under my notice some years ago. A medical friend had suffered for a year with a severe paroxysmal cough. He had lost flesh, and was regarded by his friends as rapidly passing into a decline. He informed me that he experienced a severe burning pain in the rectum, which lasted some hours after stool. On examination I discovered a fissure, for which I divided the sphincter. The cough disappeared with the ulcer, and has never returned.

The extreme sensibility of this form of ulceration is due to the exposure of a nerve-filament. The anus is abundantly supplied with nerve-filaments, from both the sacral plexus and the pudic, and hence these fissures sometimes induce irritability of the bladder, perineal and lumbar pains, disordered digestion, and, in females, occasionally paroxysms of hysteria.

DIAGNOSIS.—Fissure is often confounded with hemorrhoids, but the mistake is inexcusable. The pain, heat, and discomfort arising from piles are felt at the time of the evacuation, afterwards subsiding, and are rarely acute; the suffering from fissure sets in some time after the bowels are moved, and continues to increase in intensity for several hours.

TREATMENT.—The methods of treating fissure are by cauterization, by dilatation, and by incision. The caustics best adapted for this purpose are either the fuming nitric acid or the acid nitrate of mercury, one application of which will sometimes destroy the pain and excite healthy granulation and cicatrization. After the use of such caustics, an ointment may be applied, consisting of calomel and morphia, half a drachm of the former and three grains of the latter to an ounce of lard. If there is much rigidity of the sphincters, a little extract of belladonna may be added. Should it produce a dry mouth and throat, with dilatation of the pupils, the latter must be omitted. The bowels, while under this treatment, must be kept soluble with a confection of senna and washed sulphur.

Dilatation, the operation of Recamier, Van Buren, and others, consists in introducing the two thumbs into the bowel back to back, and then forcibly separating them from each other until the sides of the bowel can be stretched as far out as the tubers of the ischia. If the operation has been done properly, a noise may be heard of something giving way, which is due to the rupture of the mucous membrane. Both cauterization and dilatation will fail, or at least are often succeeded by relapses: consequently for years I have resorted to incision combined with dilatation, and I believe it to be an unfailing cure for the disease. The patient should have the bowels cleared out the day before the operation, by a gentle cathartic; and, as the treatment is painful, an anæsthetic should be administered, after which, the person being placed upon the side and the ulcer exposed, the surgeon draws his knife through its base, dividing a few of the underlying fibres of the sphincter. He next introduces the index finger of one hand, previously well oiled, into the anus, and entering a sharp-pointed curved bistoury three-quarters of an inch from the side of the anus, to the depth of three-eighths of an inch, pushes it onwards towards the bowel until the point is felt by the finger within, when it is made to puncture the mucous membrane and then to cut out to the surface. The knife is now laid aside, and the anus well dilated with the fingers, in order to paralyze any fibres of the lower sphincter which may have escaped division. If no vessel springs large enough to require a ligature, a piece of oiled lint or linen should be immediately placed in the wound. The subsequent treatment consists in keeping the patient in the recumbent position, and in the use of a little opium to confine the bowels. After three or four days a laxative may be given, from which time daily alvine passages should be encouraged. In seven or eight days the patient can begin to move about; but for at least two weeks he should avoid standing too long on the feet. No dressing is necessary, save that of bathing the parts with a little warm water and carbolic acid soap to remove any offensive discharges. The object of this operation is to secure rest to the ulcer by destroying the continuity of the fibres of the underlying muscle, the contraction and relaxation of which defeat all attempts at healing. There is a difference of opinion among surgeons as to the position and the depth of the incision. Some are content to divide a few muscular fibres immediately under the ulcer. I prefer to incise the entire external sphincter on one side, without reference to the ulcer, merely drawing the knife through the latter to freshen its sides. It has been proposed to divide the sphincter subcutaneously; but the extravasation of blood is liable to produce abscess in the loose tissue about the bowel. Search should always be made for polypi, and, if found, they must be removed by the ligature or by the knife; otherwise the operation for the fissure will prove unavailing.

Foreign Bodies in the Rectum.—Foreign substances may enter the rectum

in two ways,—by descending from the intestine above, or by being forced in through the anus. By whichever route the entrance is effected, the presence of such substances will often give rise to pain, tenesmus, ulceration, and abscess. Bodies which enter the rectum from above vary greatly in their character. In Ireland, in 1846, or after the blight affected the potato, there occurred many instances of large rectal accumulations consisting of the skins and diseased parts of this staple vegetable.* The stones of fruit are sometimes swallowed and finally lodge in this part of the intestinal canal. In one instance, reported by Hazelhurst,† two hundred and eighty plum-stones—almost half a peck—were removed from the rectum of a negro, where they had remained for a week. Pins or pieces of coin which are accidentally swallowed will sometimes be arrested in the rectum. The thin, flat scale from the oyster-shell, often swallowed with oysters, I have known to become fastened in the mucous membrane of this part of the bowel and produce intense distress and pain. Worms curiously intertwined with one another, forming a ball coated with mucus, occasionally collect in the rectum. Fæcal masses not unfrequently accumulate in the cul-de-sac of the gut. This is quite common in persons convalescing from typhoid fever, in whom there is often a lack of muscular power to expel the contents of the bowel. Old men, enfeebled by age or disease, frequently suffer in the same way from atony of the lower intestine. Women, after protracted labors, are frequently temporarily incapacitated for expelling the rectal accumulations, in consequence of the loss of contractility in the muscular apparatus either from pressure or from over-distention of the perineum by the fœtal head; hysterical females likewise furnish examples of impaction of the lower bowel. A singular case of fæcal accumulation is recorded‡ where the hardened mass, which when dislodged weighed four pounds, had remained in the rectum for six years.

When foreign substances enter the rectum through the anus, the occurrence is usually the result of mischief or malice, or is instigated by a hysterical condition of the body. A beggar,§ on a wager, succeeded in introducing a champagne-flask, twelve and a half inches in length and two and three-quarter inches in diameter, into his rectum, where it remained, causing great suffering, for twenty-six days before its removal. A Hindoo,‖ while in a drunken frolic, had a glass goblet, three and a half inches long and two and five-eighth inches in diameter, pushed into his rectum by a lewd woman. It was subsequently broken, and extracted piecemeal. Marchetti records a singular case, in which some mischievous students introduced a pig's tail, with the bristles cut short, into the rectum of a "woman of the town."

Symptoms.—The symptoms which indicate the presence of foreign substances in the rectum differ according to the nature of the offending material. When these consist of bones, scales of oyster-shell, or other pointed or sharp bodies, they cause pain and inflammation of the mucous membrane of the bowel, accompanied by tenesmus and sometimes bloody discharges. When there is an accumulation of hardened fæces, it is indicated by a sense of fullness and weight in the bowel, a constant desire to go to stool, spasm of the sphincter ani, pains in the lumbar region, and frequently the passage of small liquid discharges. It is this last sign which so often misleads both the friends and the physician, who suppose that these frequent thin passages are evidence of an unobstructed intestine and are to be regarded as a diarrhœa, to relieve which I have known opium to be administered for some time. When large bodies, such as tumblers, billets of wood, pointed sticks, and other similar articles, are thrust into the gut, they give rise to great distress and pain, and occasionally to peritonitis and collapse.

* Lancet, January, 1849, and January 19, 1850.
† Hazelhurst, American Journal of the Medical Sciences, Oct. 1852, p. 569.
‡ Gazette Médicale de Paris, July 20, 1849.
§ Pollock, Wien. Med. Presse, 1869, No. 8.
‖ Parker, American Journal of the Medical Sciences, April, 1849, p. 409.

Treatment.—The ingenuity of the surgeon will often be taxed to dislodge these substances. If a bone be fixed across the rectum, a finger inserted into its cavity will be sufficient to disengage one end and render extraction easy. Often, however, foreign bodies become buried in the folds of the mucous membrane from inflammatory swelling, and cannot be displaced in this way. When this is the case, the offending substance should be divided, and the pieces removed separately. This is readily done by conducting a pair of blunt-pointed bone-forceps to the body, along the finger inserted into the bowel, and cutting it in two parts, or by dilating the sphincter with a trivalve or a sinus speculum and cutting it under the eye. Small bones can be severed with a pair of blunt-pointed scissors. Rings can be hooked out with the finger. When the body is large, and of a shape badly adapted for manipulation, the patient should be placed under an anæsthetic, and, a quantity of sweet oil having been thrown into the bowel, the sphincter should be well dilated with the fingers, after which the removal may be effected by blunt hooks or strong forceps, similar to those used for the extraction of stone from the bladder. It may be necessary to break the body and remove it piecemeal; or, if it is very rough, and likely to wound the bowel in the removal, it should be secured by long forceps, and a cylindrical speculum run down over its surface before extraction, the plan practiced in Marchetti's case already mentioned. Hardened fæces require to be broken up and hooked out with the finger. If a portion of the mass is too high up for the finger, a metal scoop may be employed. Generally after a portion is removed the remainder can be got rid of by the use of injections of flaxseed-tea or soap-and-water. Ox-gall has been recommended as an enema in such cases, from its solvent action upon feculent matter; but it is of little importance. Anæsthetics should not be given, as a rule, in cases of fæcal impaction, since, after breaking down the mass and using enemata, we require the expulsive efforts of the patient, which he is usually able to make as soon as the bulk of the accumulation is diminished and the distention of the bowel lessened. When the rectum is infested with worms, their expulsion may be effected by injections of turpentine, creasote, or carbolic acid, with some mucilaginous fluid, like slippery-elm or flaxseed-tea. The tender and swollen condition of the bowel which follows operations for the removal of foreign bodies is best allayed by a small injection of starch-water with a few drops of laudanum.

Irritable Rectum.—When the rectum becomes intolerant of the presence of fæcal matter or of flatus, and manifests a disposition to expel such contents oftener than is natural, it is termed an irritable rectum. In addition to the frequent desire to defecate, there is generally some soreness at the verge of the anus and an uncomfortable sense of fullness and heat in the rectum. The irritability may be constant or only occasional. Females appear to be the subjects of the disorder oftener than males. It is rarely found except in persons of a nervous and excitable temperament. A careful examination of the anus and rectum will often fail to discover any structural change which can explain this condition, and we are compelled to regard it as one of reflected irritation.

The most probable sources of such irritation are enlarged prostate, urethral stricture, constipation, and disorders of the digestive organs. I have seen cases which arose from emotional causes, in which a person on the eve of making an address would be seized with an irrepressible desire to evacuate the bowels. The irritability of the rectum in such instances is due to the increased peristaltic activity, which hurries the fæces into the lower bowel other than in the normal quiet manner.

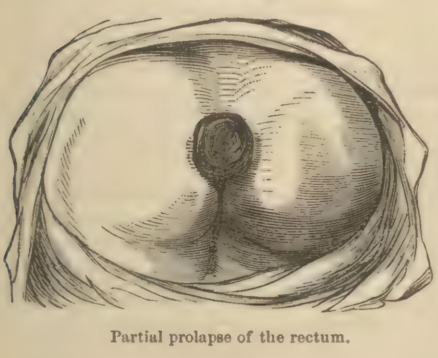
Treatment.—In cases of this nature, a patient and searching examination of the rectum should be made, in order to ascertain if there is any local cause for the irritation, and, if so, to remove it, after which the disease will most probably disappear. To relieve the local irritability for the time being, nothing answers so well as a small enema of starch suspended in lukewarm

water, thrown into the bowel, and to be permanently retained. Should this be rejected, it will be proper to add fifteen or twenty drops of laudanum to the injection, which usually secures its retention. In one case of a very troublesome nature, where every possible source of reflected irritation had been searched for and removed, nitric acid was applied with success to a very circumscribed portion of the mucous coat of the rectum, which differed from the other parts of the membrane only in being slightly increased in redness.

Dilatation of the Rectal Pouches.—At the lower part of the bowel, a short distance above the anus, the mucous membrane is thrown into a number of perpendicular ridges or folds, which, joining below, form a series of small pouches, which are in a great measure effaced by distention. The anatomy of this part of the intestine was long since carefully examined and described by Professor Horner. The surgical importance of these sacs was first noticed by Professor Physick, under the term "*encysted rectum*." He found that to their dilatation and inflammation were to be ascribed several unpleasant sensations complained of by patients, such as pruritus, vermicular movements within the anus, and pain after stool, extending from the bowel to the nates and thighs. The disease is most commonly found in persons advanced in life and of a costive habit, or in whom the fæcal accumulations have been too long retained in the rectum from inertia of the muscular apparatus of the bowel. These pouches once dilated admit, it is said, of the entrance of small seeds, inspissated mucus, and other foreign matters, thus giving rise to the symptoms above noticed. The disease is certainly very rare. In cases, however, of an obscure and ill-defined trouble at the lower end of the intestine, it will be proper to examine these pouches, in order to ascertain if any foreign substances have become arrested. This is accomplished best by the method of Physick, which consists in bending the end of a pocket probe into a hook, passing it up the bowel, and then withdrawing it, with the point against the mucous surface. If the sacs are enlarged, they can be drawn down, and if at the same time the patient strains, they can be brought outside of the anus, when, if necessary, they may be clipped off with a pair of scissors. I have very frequently examined the rectum with a view to discover this state of its pouches, but have never been successful, either in the dead or in the living.

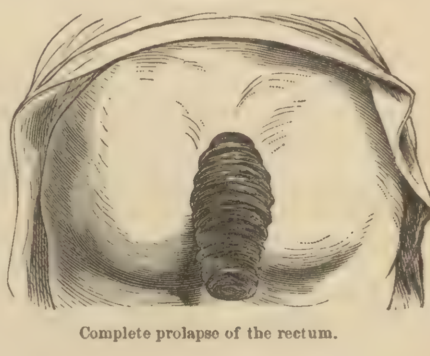
Prolapsus Ani et Recti.—There are two varieties of prolapsus recti, the one *partial* and the other *complete*. In the first there is merely a more or less

Fig. 270.



Partial prolapse of the rectum.

Fig. 271.



Complete prolapse of the rectum.

complete circular protrusion of the mucous membrane through the anus. (Fig. 270.) In the second the rectum in its entirety—that is, including all its tunics—is protruded through the anus. (Fig. 271.) In either condition, when the prolapse is well pronounced, the circular and the concentric dupli-

catures of the mucous membrane of the intestine will be quite marked. (Fig. 272.)

The disease is much more common among children than among adults, and is caused by diarrhœa, constipation, ascaridal irritation, polypi, dys-

Fig. 272.

Concentric folds of a prolapsed rectum.

entery, crying, coughing, and very often by the presence of urinary calculus. The habit among nurses or mothers of allowing children to sit at pleasure upon the commode or the chamber conduces to the production of the disease. In addition to these causes, the anatomical conformation of the sacrum and the rectum in children predisposes to such displacements. Both the bowel and the bone are much straighter than those of the adult, and in consequence the muscular force exerted in the act of defecation acts more directly upon the outlet of the bowel. In the simple or incomplete variety, the protrusion is produced by the elongation of the submucous connective tissue, which frequently contains a considerable amount of serum, constituting an œdematous state of the parts. When the protrusion remains out for any great length of time, the gut undergoes considerable structural alterations. The mucous membrane, at first red, soft, and moist, becomes paler, hard, and dry; its folds are in a measure effaced, and lose their pliability by inflammatory deposition in the submucous tissue, producing much thickening; while the surface becomes dark and rough, with here and there an adherent crust or scab.

The causes which produce prolapsus recti in adults and in aged persons are of a different nature from those operating in childhood. Any obstacle to the passage of the urine, such as stricture or an enlargement of the prostate body, predisposes to the disease. Chronic coughs have a similar tendency, and so also has the habitual use of injections. There is a weakness of the sphincters, and indeed of the entire muscular apparatus of the perineum, especially in persons far advanced in life, which also gives rise to prolapse of the rectum. I attended a lady, ninety-seven years of age, for fracture of the thigh at the lower third of the bone. The shock attending the injury produced great muscular debility, and especially of the sphincters of the anus and the rectum. A prolapse of the bowel followed, to a degree which I had never before witnessed. It increased from day to day until it extended through the opening in the fracture-mattress, and was received in a wooden bowl which I had placed beneath the bed, supported upon a stool. It was a complete invagination of the entire rectum and a portion of the sigmoid flexure of the colon, and measured at least twelve inches in length. Under the use, twice a day, of a decoction of oak-bark, applied by means of a syringe,

and afterwards brushing over its corrugated surface some olive oil, it began gradually to retract, and in six weeks was entirely reduced. Hemorrhoids are frequently associated with procidentia of the rectum. There are persons who possess the power of extending and retracting the rectum at pleasure. I once had under care a soldier who was in the habit of amusing his comrades by bending forward, protruding the bowel to the extent of six or seven inches, and then with equal facility restoring it to its proper position. In recent cases of procidentia, the displaced bowel may become strangulated by the grasp of the sphincters.

Treatment.—In the treatment of procidentia recti, it is of primary importance to ascertain the cause of the disease, the removal of which is often alone sufficient to effect a cure. If there is evidence of the existence of worms infesting the rectum, they should be removed by anthelmintics. An injection into the bowel of turpentine or of carbolic acid, suspended in some flaxseed-tea, will prove efficacious in expelling these parasites. Should there be found a vesical calculus or a rectal polypus, its removal will effect a cure. If diarrhœa is present, it must be treated by the use of the hydrargyrum cum creta, followed by Dover's powder, in order to restore the healthy intestinal secretions and quiet the peristaltic action of the bowels; if there is constipation, it is to be treated by the confection of senna and sulphur. When none of these causes exist, and the disease is the result of feeble health, our remedies must be directed to the improvement of the constitutional vigor of the patient. The diet must be nutritious and the patient be kept much in the open air. The remedies best suited for internal administration are iron, cod-liver oil, pepsin, and strychnia, or some of the bitter infusions with dilute phosphoric acid.

Local treatment will often become necessary, both as a temporary and as a permanent measure. As the cases which we are now considering are for the most part met with in young subjects, our instructions must be carried out through a nurse or mother. Care must be taken that the child evacuate the bowels in the recumbent position, and on the side in preference to the back, in order to diminish the pressure exerted by the diaphragm, abdominal muscles, and the intestines against the perineum and upon the lower end of the bowel. If the protrusion follows, and does not recede spontaneously, a stream of cold water or of a decoction of oak-bark should be thrown upon the mucous membrane by a syringe, and the part carefully returned by oiling two of the fingers and with their palmar surfaces pressing it within the sphincter, afterwards applying a pad and T bandage. These measures, if persevered in for a few weeks, will generally effect a cure. If, notwithstanding this treatment, the disease persists, the bowel coming down on any trifling exertion, or remaining out in spite of all efforts to the contrary, a more active procedure will be necessary. We have the choice of three remedies: submucous injections of ergot, cauterization, and the knife. The use of ergot should be first tried by introducing into the submucous tissue of the rectum six or eight drops of a concentrated fluid extract, each drop of which will represent one grain of the ergot. These injections are to be repeated every second day for two weeks. Should this fail, cauterization must be tried. There are three articles belonging to this class of remedies which are used for this purpose,—nitric acid, acid nitrate of mercury, and nitrate of silver. I much prefer the first mentioned. The pain following its application is not very severe, nor is its duration long; and the remedy appears to be peculiarly adapted to the mucous surfaces of the rectum. In applying it, an anæsthetic should be administered to the child, the part thoroughly cleansed, and the fuming acid freely applied with a little mop to the entire surface of the extruded gut, taking care to avoid the skin. The cauterization should be immediately followed by the free use of sweet oil, and the bowel restored. To prevent its descent when the effects of the anæsthetic are over, a quantity of soft cotton-wool should be introduced into the rectum, a compress laid over the anus, and the buttocks drawn tightly together by means of adhesive plasters passed

from one to the other. This is the method of Allingham, and will be found in most cases to prove successful. To prevent straining, allay irritation, and keep the bowels quiet, paregoric should be given in doses sufficient to have the desired effect. After the fourth day the external dressings are to be removed, and a dose of oil administered, the action of which will bring away the cotton-wool.

In the case of adults, the disease is often very obstinate and much less manageable than in children. The rectum should be carefully examined, to see if any growths, such as polypi or hemorrhoids, are present, causing the prolapse; and if such are discovered, they should be removed, as preliminary to other treatment, the operation probably effecting a cure. If a urethral stricture exists, it will be necessary to dilate the canal; if the prostate offers an obstacle to the flow of urine, it will be better to avoid the straining, when great, by the occasional use of the catheter. In cases where none of the above causes operate to produce the disease, the alternative is a resort to cauterization or to the removal of some of the redundant portions of the mucous membrane. Cauterization, in my hands, has not proved very successful. In one instance in which the nitrate of silver was used, the suffering which followed was exceedingly severe and prolonged, occasioning sloughing, severe chills, fever, delirium, and extreme prostration, from which the patient did not recover for many weeks. Though the prolapse was cured in this case, it wellnigh cost the patient his life. In two other instances in which this salt was applied to the bowel, the distress was agonizing and without benefit. Dr. Van Buren recommends linear cauterization with the hot iron, the resulting cicatrices serving to contract the bowel. In adults, and particularly in aged persons, there is less risk from an operation than from cauterization, and it is preferable to adopt some one of the various modifications of Copeland's plan, which consisted in removing by ligature elliptical portions of the mucous and submucous structures of the prolapsed bowel. The most satisfactory of these is either to excise two or three ovoidal portions of the mucous folds with a pair of scissors curved on the flat, and unite the divided parts by the interrupted suture; or, what is preferable, to pinch up in two or three places the excess of tissue with a Smith's clamp,—as is shown under the head of piles,—and cut off the folds a short distance in front of the instrument, applying to the stump the actual cautery.

In bad cases, where remedies have proved unavailing, or where patients have declined an operation, much good may be done by douching the parts with cold water and applying an oiled compress supported with a T bandage, which will not only prevent further protrusion, but will also protect the patient's clothing from being soiled by the discharge of the intestinal mucus. In some cases of prolapse the insufficiency of the sphincters is such as to allow a degree of fæcal incontinence, for which it may be necessary to administer astringents conjoined with small doses of an opiate.

Polypus of the Rectum.—Two varieties of polypi are found in the rectum,—the soft or *gelatinoid*, and the firm or *fibroid*. The former, doubtless, is much more common than the latter: it is the only variety met with in children. These gelatinoid polypoid growths are quite as frequently seen in adults as in children. The appearance of the first variety differs from that of those which infest the nasal cavities in being more firm and having a red color. They are made up of fine connective tissue and of hypertrophied follicles, with numerous vessels, and are clothed with a round epithelium. They are only exaggerated outgrowths of the normal anatomical elements of the mucous and submucous structures of the intestine. The fibroid variety consists chiefly of dense, compact, interlacing fibres of connective tissue and of blood-vessels. These growths are generally pedunculated, rarely sessile. The pedicle is sometimes one inch or more in length, and may be so slender as to break away in the act of straining at stool. They will occasionally protrude

from the rectum, and require to be replaced like a pile. They are both single and multiple, and vary in size from that of a pea to that of a hickory-nut.

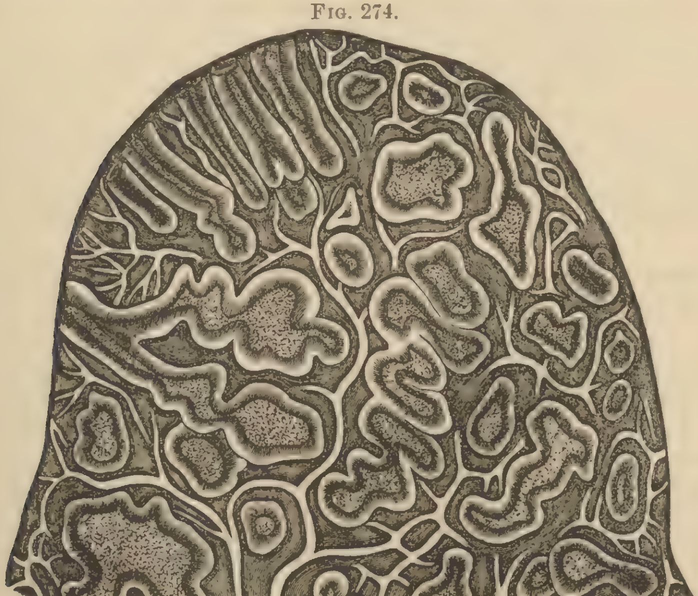
Rectal polypi differ both in form and in external appearance. They may be either round or fusiform in shape. (Fig. 273, *a* and *b*.) They are sometimes red, and at other times have a dark-blue color. In some instances they are covered with numerous little eminences, resembling the surface of a raspberry or a mulberry; in other cases they are perfectly smooth, and in others again are beset with numerous little villous processes, similar to those belonging to the mucous membrane of the small intestine. The villous structure is occasionally so pronounced that it might with propriety be designated as the villous polypus. I once removed from a merchant, living in an adjoining State, a growth of this kind (Fig. 273, *c*), which had, in consequence of severe pain and frequently-recurring hemorrhages, entirely disqualified him for business. He recovered his health and strength rapidly after the operation. It is not uncommon to find a polypus in the midst of a cluster of piles, and in cases of fissure they are frequently present.

Fig. 273.

a, fusiform polypus; *b*, round polypus; *c*, villous polypus.

Structure of Rectal Polypi.—These growths are true adenomata, and consist of dilated Lieberkühn glands of the mucous membrane of the rectum, imbedded in connective tissue, with numerous blood-vessels, and covered with the ordinary epithelium of the bowel. (Fig. 274.) The glands which

Fig. 274.



Structure of an adenoma or mucous polypus of the rectum.—From Billroth.

constitute so large a portion of these bodies are frequently dilated into sacs. Rectal polypi and the nasal mucous polypi are almost identical in structure.

Symptoms.—A polypus may exist in the rectum without its presence being suspected, so little inconvenience does the patient experience. This is likely to be the case when the pedicle is short, and its movements, in consequence, restricted. When the foot-stalk becomes sufficiently long to admit of the descent of the growth into the anus, it gives rise to much uneasiness, which may finally amount to tenesmus. There will in such cases be a frequent desire to go to stool, and during the attempt at defecation a body comes down and protrudes externally, which is often mistaken for hemorrhoids or for a prolapse of the bowel. When these polypi become abraded or inflamed, they will bleed very freely, and furnish an ill-formed and offensive muco-purulent discharge, which excoriates the parts about the verge of the anus. In cases where there is tenesmus and the feeling of a movable body in the rectum, with the discharge of blood and mucus, and without any protrusion, a careful examination of the bowel should be made to determine the cause. The insertion of a finger into the rectum will frequently enable the surgeon to detect one of these growths or its pedicle; or if a full injection of tepid water be thrown up the bowel, all obscurity as to the nature of the disease will be generally removed by the descent of the polypus with the expulsion of the enema. In cases where an operation has been unsuccessfully performed for the cure of anal fissure, the existence of a polypus may be suspected, the removal of which will be necessary to effect a cure of the ulcer. Children who lose blood at stool, although no growth is visible, may be suspected to labor under polypus, and should be carefully examined at the time of stool or by using the water injection.

Treatment.—Polypi may be removed either by the ligature or by the clamp and cautery. In the first method, the bowel being emptied by an enema, the growth must be secured as it appears, and, being drawn down with the fingers or by a pair of forceps, should be strangulated by a ligature tightly tied around its pedicle. Thus secured, the body may be cut off. After the operation the patient should remain in bed and the bowels be kept quiet for five or six days, after which a laxative may be administered, the action of which will bring away the ligature. If the clamp be employed, the blades of the instrument must embrace the pedicle of the growth and be screwed down tightly. The polypus is next cut away three-eighths of an inch in front of the instrument, and the stump thoroughly cauterized with the hot iron to prevent bleeding, after which the clamp may be removed. The patient had better remain in bed for thirty-six hours subsequent to the operation. Removal of polypi by the knife or by the scissors, without the ligature or the cautery, should not be countenanced in general practice, as a very troublesome bleeding may follow.

Ulceration of the Anus and of the Rectum.—There are ulcerations of the anus which are quite different from fissure in appearance, causes, and effects. The entire verge of the bowel will in some instances present a ragged, chapped appearance; or just within the cutaneo-mucous junction will be seen an ulcer of an oval and sometimes irregular form, having thickened borders, and its bottom presenting a grayish color. The integument immediately around the anus is often red and moist. In consequence of excoriation or the presence of eczema, the heat, smarting, and itching experienced are sometimes very annoying. Though the sensibility is much exalted, it is not common for patients to suffer to the same degree as in fissure. There are many causes which operate to produce anal ulceration, among which may be named constipation, chronic diarrhœa, and vaginal discharges, especially from gonorrhœa or from constitutional syphilis.

When ulceration is situated higher up, either just below the internal sphincter or above that muscle in the rectum, we have a much more formidable disease. Such ulcers may be single or multiple. They are caused by strumous and syphilitic conditions of the general system, by traumatic injuries, and occasionally by chronic dysentery.

Symptoms.—Ulceration of the rectum is a very insidious disease. It is developed slowly and with so little suffering that it may make much progress before it is detected. Among the earliest signs of its existence is a tendency to morning diarrhœa, the patient being obliged to seek the water-closet immediately on rising from the bed. At first the passages are free and semi-consistent, but after a time become scanty and watery and are accompanied with much flatulence. As the disease advances, a tenacious white gelatinous material is discharged, sometimes mixed with a purulent or muco-purulent matter. Until this is gotten rid of, the patient will suffer pain and tenesmus, after which he may enjoy comparative comfort for many hours, or until another accumulation like the last takes place.

The progress of the ulceration will in time increase the tendency to diarrhœa and aggravate the local distress. The patient is harassed with flatulence and griping pains, the strength begins to fail, pains radiate along the thighs and perineum, and the body loses flesh. These ulcers may be detected by the insertion of the finger into the bowel, but much more satisfactorily by introducing a speculum and exposing in a good light the interior of the intestine, when they will be seen varying in size, having elevated and thickened edges, their surfaces presenting a dark-red color, and occupied by indolent granulations or covered with a gray substance consisting of the débris resulting from the death of the reparative material. These ulcers are prone to extend upwards in the rectum and downwards towards the anus, the latter being vastly more painful than the former. At the same time the surrounding induration increases, the discharges become bloody and purulent, and knots of inflammatory thickening will be seen scattered over the mucous membrane at different points contiguous to the ulceration.

The disease is by no means limited to the mucous membrane: it extends to the submucous tissue, and in aggravated cases attacks and destroys the muscular structure of the bowel, causing incontinence of both the flatus and the fæces, and subsequently producing coarctation or stricture of the bowel. In numerous instances the ulceration has opened into the vagina and into the bladder. Patients may continue for years with this disease, dragging out a miserable existence, and finally die, either from a diffuse pelvic cellulitis or from peritonitis.

Treatment.—In the treatment of anal or rectal ulceration, the cause of the disease must first be ascertained. If it has a syphilitic origin, it will be necessary to administer alterative remedies, such as the iodide of potash or one of the preparations of mercury, or both combined. Under the use of these remedies alone I have succeeded in curing some very aggravated cases of this disease. If there is reason to believe the case to be of a strumous origin, the use of cod-liver oil and the iodide of iron will be indicated. Many cases occur which it is impossible to trace to either of the above causes, and where we must be governed in our treatment by a comprehensive view of all the possible sources of irritation. If the case is a recent one, it may be brought to a successful termination by attention to the digestive organs, with very little local treatment. Imperfectly-digested food, vitiated intestinal secretions, and stimulants, all exert a damaging influence upon these ulcerations. The bowels should be acted upon by a few grains of blue mass, followed by some castor oil. The rectum must be washed out with an enema of flaxseed-tea, and afterwards one or two ounces of starch-water thrown up, containing fifteen to thirty drops of laudanum, to be retained, which will produce a very soothing effect on the bowel. This injection may be used daily, should the diarrhœa demand it. When the evacuations are not too frequent, the starch and water, without the anodyne, will prove very comforting to the sensations of the patient, as it serves to shield the mucous surface from irritating secretions. The diet should be highly nutritious, and of such a nature as to supply but little effete matter. Nothing so perfectly meets these requirements as unskimmed milk, either plain or scalded, and

to this the patient should be rigidly confined, it being taken at pleasure. Flatulence, which is so common in rectal disease, is best relieved by compound tincture of cardamom and the fluid extract of chamomile, or by the time-honored remedy of carbonate of magnesia and powdered charcoal. A hot hip-bath for twenty minutes, twice or thrice a week, will prove useful, and absolute rest in the recumbent position must be rigidly enforced. In more advanced cases of the disease, it will be necessary to make a direct application of remedies to the ulcer. For this purpose I am partial to the acid nitrate of mercury, and, next to this article, to pure nitric acid. The use of nitrate of silver has never proved entirely satisfactory in my hands. The ulcer must be exposed by the speculum and the acid freely applied with a mop of cotton, after which the starch and laudanum should be immediately injected into the bowel. Once or twice a week is often enough to use the remedy, and as soon as there is evidence of an improvement in the disease it should be discontinued, or should be applied only at long intervals. When the ulceration extends into the deeper structures of the bowel, and is followed by contraction or by stricture, dilatation by graduated rectal bougies will become necessary.

Stricture of the Rectum.—Strictures of the rectum are of two kinds, the *non-malignant* and the *malignant*.

Non-malignant Stricture.—This division includes all contractions or narrowings of the bowel having a traumatic origin. *First.* Many cases are caused by abrasions and lacerations of the mucous membrane by the improper use of clyster-pipes, by a too extensive removal of tissue in the operation for piles, by forcing foreign bodies into the rectum, and also by sharp-edged or sharp-pointed substances, such as scales from oyster-shell or a fragment of bone, becoming entangled in the folds of the lining membrane of the intestine. Hardened fæces are said to cause stricture very much in the same way; but I have never seen a case which could be properly referred to such an origin. *Second.* The disease may result from the cicatrization of extensive ulcers of the rectum, or of those which follow the cauterization of the mucous coat in prolapsus ani. *Third.* Stricture may be secondary, by an extension of inflammation from the surrounding cellular tissue to the coats of the bowel. I have seen two cases of stricture of the rectum succeeding a very bad fistula in ano, in which the perineal structures were traversed in different directions by sinuses. *Fourth.* Stricture not unfrequently follows both primary and secondary syphilis: in the first by unnatural intercourse, and in the second by inflammatory deposition, ulceration, and cicatrization. Accidents common to mucous and submucous tissue form constitutional infection. Under this head comes the horseshoe ulcer of Sir James Paget. Uterine displacement, as retroversion, pelvic tumors, and enlargements of the prostate body, have been improperly described as causes of stricture. They often do encroach upon the rectum, pressing its walls together and interfering with the passage of fæces; but this is obstruction, not stricture; it is mechanical, not organic, in its nature. There is also a spasmodic stricture described which is purely reflex, caused by the irritation of an ulcer, and is temporary in its duration. I have seen stricture of the rectum follow contusion of the bowel in consequence of the delay of the fœtal head in the pelvic cavity.

Except from syphilitic causes, non-malignant stricture of the rectum is not a common disease; and it is for the most part confined to middle life. Females are more frequently affected than males. The structural changes in the coats of the intestine differ in different cases. Sometimes the disease appears to involve only the mucous and submucous tissues, giving rise to an annular elevation or valve-like projection. Under the head of intestinal obstruction will be seen a cut (Fig. 255) illustrative of such a variety. Sometimes the inflammatory infiltration is chiefly in the muscular walls of the rectum, and becomes gradually transformed into a dense fibrous tissue, extending some

distance up and down the bowel. (Fig. 275.) In two cases recently under my care, the thickening was confined wholly to the submucous and muscular tunics, the mucous membrane remaining perfectly smooth. (Fig. 276.) The disease, as it encroaches upon the cavity of the intestine, may be very circumscribed, constricting it like a cord, or it may extend up and down the bowel for some distance. The resistance offered by the obstruction provokes strong expulsive efforts on the part of the patient, which produce not only hypertrophy of the muscular walls not implicated in the disease, but also often a marked dilatation of the intestine above the seat of disease.

FIG. 275.

Fibrous stricture of the rectum.

FIG. 276.

Stricture of the rectum.

SYMPTOMS.—Stricture doubtless may be present in some cases a long time before being suspected, so little inconvenience is experienced. Usually, however, the patient is conscious of some uneasiness in the rectum. There is constipation, with more than ordinary difficulty in passing the stool,—a feeling as though the act had not been completed. Sometimes there is diarrhœa alternating with constipation. The fæces are often discharged in broken fragments, or they may be wire-drawn, coming out in pencil- or pipe-like form, and sometimes they are flattened or triangular. The last two forms are by no means indicative of stricture, as I have often seen the evacuations assume these shapes from the mechanical pressure of an enlarged prostate or from a uterine fibroid. As the disease advances, ulceration takes place, followed by a discharge of blood and of a gelatinous or muco-purulent fluid. This discharge stains the clothing, and irritates and excoriates the parts about the anus. The pain becomes more severe, shooting along the penis, thighs, and upward to the small of the back. Patients often complain, after defecation, of exhaustion and a peculiar sense of "goneness" about the epigastrium. The digestive organs become deranged, as is manifested by slight

nausea, loss of appetite, flatulent distention of the bowels, and a gradual loss of flesh. The inflammation may extend beyond the limits of the gut, and result in peri-rectal abscesses opening into the cavity of the intestine above the stricture, or below upon the surface of the perineum, and even into the bladder or into the urethra, and in the female into the vagina, proving finally fatal by wearing the patient out from irritation and suppuration or by exciting a destructive peritonitis. The local exploration of the parts furnishes, however, the only decisive evidence of stricture. Mr. Colles, as a sign of rectal stricture, attaches some importance to a peculiar prominence which joins posteriorly and separates anteriorly on each side of the anus, giving to the outlet of the bowel an appearance not unlike that of the mouth of a ewer. When the finger is introduced into the intestine, should a stricture be present, the obstruction will in most cases be encountered within the first two or two and a half inches. It cannot well be mistaken. The finger readily recognizes the encroachment upon the canal, and may, by a little pressure, be carried through and beyond the diseased portion.

In cases where the disease is situated slightly beyond the reach of the finger, the patient should be urged to bear down forcibly while in the standing position, slightly bent forward, when the stricture may be brought sufficiently low down to be within command of the touch. Where the disease is still farther up, a long speculum will sometimes disclose its existence. The use of bougies as a means of detecting rectal stricture is of doubtful value. The information they impart is very indefinite. Their liability to become entangled in the folds of the bowel, or to strike against the promontory of the sacrum, may be urged against their employment. I have known several instances in which strictures have been predicated from the resistance offered to the passage of a bougie, where nevertheless the bowel was afterwards found to be free.

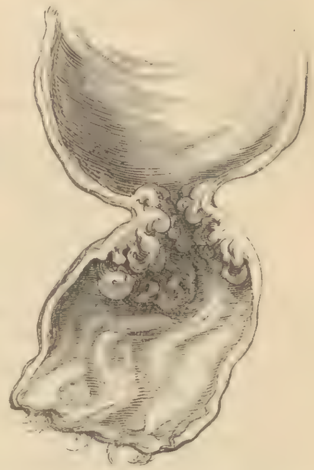
Malignant Stricture, or Cancer.—This, in my experience, constitutes a very large proportion of all cases of stricture of the rectum, and it is among the most terrible afflictions to which the human body is subject. The disease is met with chiefly in middle and advanced life. Whether males or females suffer most is a question upon which authors differ. Ten cases out of eleven admitted to the Hôtel-Dieu, Paris, Desault tells us, were in females. Curling records sixty-seven cases of rectal cancer, forty-four of which were in males. Mr. Copeland believed that women were most frequently the subjects of the disease. Allingham has seen the disease oftener in men than in women; Professor Gross's testimony is to the same effect; and in my own experience a very large proportion of cases has been in males.

The seat of cancer of the large intestine is generally within reach of the finger. Most commonly it is found about one inch and a half above the anus; next in order of frequency, about two and a half or three inches from the outlet of the bowel; and, last, in the sigmoid flexure. In its progress the disease does not appear to be influenced by gravity, as the tendency is to extend upwards rather than downwards. The forms under which it appears are the epithelial, the scirrhous, and the medullary.

The *epithelial* form of the disease is by far the most common. It may commence at the anus and extend upwards to the intestine, or it may be primarily seated in the rectum. When situated at the anus, this affection may linger for many months at the junction of the skin and mucous membrane before assuming an aggressive form. The disease, like that on the lip, in its commencement presents different appearances. There is sometimes a circumscribed, hard, flat mass seen at the cutaneo-mucous junction, with a gradually-extending induration. Sometimes there will be found a crack or a small ulcer with ragged borders, attended with little pain, and which, were it not for the surrounding infiltration, might be confounded with a fissure; in other cases it appears as a warty growth. Whatever may be its early appearance, as it advances irregular tuberous masses form, ulcerate, and split

like warts into numerous papillary or cauliflower eminences, while from the raw surface and the intermediate clefts a muco-purulent fluid is discharged, and not unfrequently a profuse hemorrhage takes place from the surface of the rapidly-growing mass. In its progress the anus and the lower part of the rectum may become filled with a luxuriant fungoid growth, so as seriously to obstruct the escape of the fæces. (Fig. 277.) Epithelial cancer of the rectum cannot be deemed a rare disease. Every year I witness several examples, and generally in persons between thirty-five and fifty years of age.

FIG. 277.



Epithelial cancer of the rectum forming cauliflower outgrowths.

Scirrhus of the rectum begins two or three inches above the internal sphincter, most probably in the submucous connective tissue, and infiltrates all the tunics of the bowel, encroaching upon its cavity and pushing out the mucous surface into irregular hard nodules. These nodules not unfrequently ulcerate and form raw, bleeding surfaces or ulcers with indurated and ragged edges, and the infiltration and contraction which follow serve to produce stenosis of the canal of the bowel. Scirrhus of the rectum tends to extend peripherally, so that it is not uncommon to find the contiguous organs, as the bladder in the male and the vagina in the female, implicated in the disease, and all bound and matted together in one mass of inflammatory and carcinomatous material. It is from this tendency that we so frequently witness communications taking place between the rectum and the surrounding organs, by which the contents of the bowels pass into the urinary bladder or into the vagina, adding greatly to the distress of the unfortunate patient. The same cause occasionally produces abscesses and fistulous openings through the perineum. In some cases the rectum becomes secondarily involved, the disease beginning in the vagina or uterus and extending to the bowel.

Encephaloid cancer of the rectum, though not common, is occasionally seen. A well-marked case of this nature was recently under my care, in the person of a female about sixty years old. The rapidly-growing mass showed little tendency to infiltrate the coats of the intestine. It filled the rectum, and destroyed the patient in four months, from hemorrhage and from blood-poisoning.

SYMPTOMS.—Ano-rectal cancer may exist some time before the disease is suspected. In the epithelial form it is at first supposed to be hemorrhoids, but the induration, ragged protuberances, and indisposition to yield to ordinary applications will reveal its true character. When the rectal portion of the tube is the seat of the disease, there will be some uneasiness experienced in the part, and some difficulty in passing the evacuations, accompanied with straining and an irritable state of the urinary bladder. The fæces will be altered in form, becoming unnaturally small, and will be forced out in broken pieces. Small liquid discharges, intermixed with particles of fæcal matter, are frequently passed, conveying the impression of the existence of a troublesome diarrhœa. The pain becomes more severe, is burning and lancinating, and extends to the back, perineum, bladder, penis, thighs, and buttocks. Mucus or muco-pus streaked with blood is passed from the bowel, and, when the fungous granulations are present, a watery discharge, having an offensive, sickening odor, escapes involuntarily from the anus. As the obstruction increases, the patient suffers from a sense of fullness at the lower part of the abdomen, with flatulent distention. The further progress of the disease is marked by loss of appetite, of strength, and of flesh; the complexion assumes

that straw color or that sallow hue which reveals so unmistakably the malignant nature of the affection.

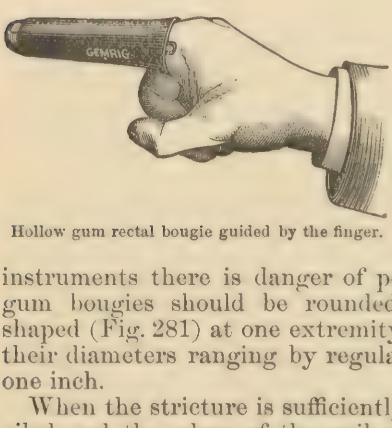
The local signs of the disease cannot be well mistaken. When the finger is carried into the bowel a short distance, it encounters an abnormal growth, which may be confined to a portion of the intestine or involve its entire circumference, the surface of which may be smooth and moderately uniform, or irregular and rough, and which in either case is indurated. When ulceration has taken place and fungoid outgrowths are studded over the intestinal surface, the sensation imparted is very peculiar. It is that of a finger breaking through a moist, friable, nodular, spongy mass, and unlike that experienced from contact with any other morbid product. Once felt, it will never be forgotten. When the growth is of the fungoid or cauliflower form, the bowel is often changed in its direction, and the opening through the midst of the diseased mass can be discovered only after a search in various directions: in such examinations the finger will, when withdrawn, be found covered with blood mingled with an unhealthy, offensive, muco-purulent material.

Cancer of the ano-rectal region has only one termination, and that a fatal one. It may run its course in five or six months, or death may not occur until the lapse of two or even three years. The patient dies, worn out by pain and irritation, blood-poisoning, and secondary deposits in the liver, lungs, and other organs, sometimes by peritonitis, and in exceptional cases by hemorrhage.

TREATMENT.—The treatment of non-malignant stricture is accomplished by *dilatation* and by *incision.*

Dilatation.—This may be effected by the finger alone, or by the finger armed with hollow rubber cylinders of different sizes, each having a little opening in its extremity for the tip of the digit, in order that the instrument may be intelligently directed by the sensations of the operator. (Fig. 278.) When the stricture is situated at an inconvenient distance from the anus for the use of the finger, graduated metallic or gum bougies should be employed. The latter are to be preferred on account of their smoothness and flexibility, qualities which conduce to the safety of the intestine. With stiff, inflexible instruments there is danger of perforating the walls of the bowel. These gum bougies should be rounded (Fig. 279), conical (Fig. 280), or olive-shaped (Fig. 281) at one extremity, and about ten or eleven inches in length, their diameters ranging by regular gradation from one-fourth of an inch to one inch.

FIG. 278.



Hollow gum rectal bougie guided by the finger.

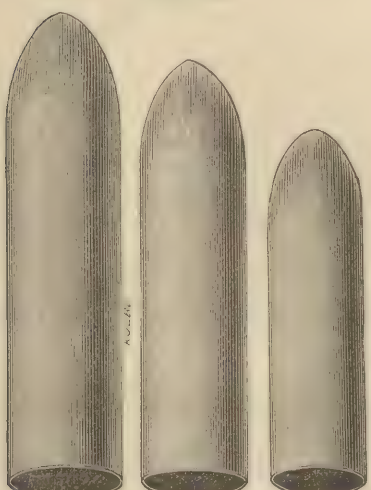
When the stricture is sufficiently low in the rectum, the index finger, well oiled and the edges of the nail protected by a layer of soap, should be inserted and carried upwards to the seat of obstruction. After a little gentle manipulation, its extremity may enter the constriction and be gradually carried through. At the next attempt the dilatation may be increased by slipping over the finger one of the hollow cylinders of gum, and at each successive attempt a larger one, until the obstruction is removed. When the disease is higher up, and cannot be treated by the digital plan, resort must be had to the graduated gum bougies, beginning with the smaller numbers and rising by easy gradations to the larger ones. There should be no attempt to accomplish too much in a short time. The work should be done gently and slowly. Nothing is gained by employing much force. The bowel, often weakened by the structural changes, may readily be perforated. If the dilatation be forced too rapidly, an inflammation is likely to be excited, which will not only render the bowel so irritable as to necessitate the suspension of all operative measures, but will also increase the strength of the stricture by

causing a new deposition of plastic material. In cases where the approach to the stricture is not direct or is somewhat devious, the surgeon will succeed in finding and passing the obstruction better with the olive-shaped instrument

FIG. 279.

Rectal bougies, with rounded or blunt extremities.

FIG. 280.



Conical-shaped rectal bougies.

FIG. 281.

Olive-shaped bougies.

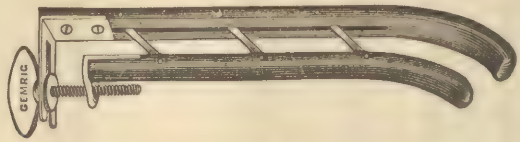
than with any other, especially when it surmounts a flexible handle. The finger should in all instances accompany bougies as far as possible. Some prefer, after passing the bougie, to have it remain for several hours in the stricture,—a practice which I do not deem necessary. The frequency with which strictures are to be dilated must be regulated by the sensations of the patient. If no undue irritation is developed, every second or third day will not be too often. In constrictions not attended with much sensibility, and where a considerable amount of force is requisite to effect dilatation, a very efficient plan is to

introduce a Molesworth elastic tube and gradually distend it by hydrostatic pressure. Allingham employs Barnes's india-rubber bags for a similar object. Strictures which are membranous or band-like, and which possess an elastic property, causing them to contract rapidly after dilatation, are best managed by division.

Division.—There are two methods of dividing non-malignant stricture,—namely, by *divulsion* and by *division.*

Several instruments have been devised for divulsion. The one represented in Fig. 282 is frequently employed for this purpose, and also for dilatation. The

Fig. 282.



Instrument for rupturing or dilating a rectal stricture.

arms of the instrument, being closed, are conducted through the constriction, after which they are screwed asunder until the parts give way. I find it more convenient, and equally effective, to use for the above purpose a pair of long forceps, such as are employed for removing uterine polypi. (Fig. 283.)

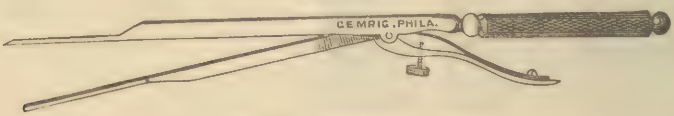
Fig. 283.

Forceps used to divulse rectal stricture.

The finger being introduced into the bowel, the blades of the forceps should be guided through the stricture, and then separated as widely as necessary.

Division may be performed, where the stricture is low, with a probe-pointed hernia bistoury, conducted flatwise along the finger through the constriction, and then, by turning its edge against the resisting membrane, nicking the same at two or three points, after which the finger or bougie, or the forceps used in divulsion, may be employed to enlarge the opening to the requisite extent. When the constriction is some distance up the bowel, the division can be more satisfactorily executed by a long, double-bladed knife. (Fig. 284.) The

Fig. 284.



Instrument for dividing rectal stricture.

cutting part of the blades is limited to about three-quarters of an inch at their free extremities, the point of each being blunt. In using the instrument, it is passed through the stricture, closed, and afterwards the blades are forced apart by pressing the lever with the thumb. In all cases where there is much sensitiveness of the bowel it is best to administer an anæsthetic before any operation is practiced.

The use of the knife in other forms of rectal stricture is not without danger, and should be discouraged. In strictures of syphilitic origin, in addition to

the local treatment by dilatation, the use of mercury, with or without the iodide of potash, is indispensable. As strictures, even when well dilated, have a strong tendency to recur, I make it a rule, as soon as the calibre of the bowel is sufficiently enlarged, to intrust the work of dilatation to the patient, with directions that a large-sized bougie be passed once every week. In order to avoid all possibility of injury to the bowel, I direct, as the simplest and safest instrument for this purpose, a tallow candle, dipped to the proper size and rounded at one extremity. During the period of dilatation the bowels should be kept regular from the very beginning of the treatment, which is best accomplished by the use of a pill, two or three times a day, consisting of one-twelfth of a grain of extract of belladonna, half a grain of extract of nux vomica, and half a grain each of rhubarb and aloes. Should this not prove sufficient, and should the fæces accumulate above the stricture, injections of warm water will be required to clear the bowel.

In the treatment of carcinomatous or malignant stricture our efforts are for the most part restricted to the alleviation of the patient's sufferings. Dilatation can be of no service so long as the fæces pass; and there are objections to the use of bougies,—the chief being the danger of perforation of the bowel and of hemorrhage. The bowels are to be kept soluble by the use of gentle laxatives, such as compound liquorice-powder or the bitartrate of potash and washed sulphur. When accumulations form above the mass occupying the rectum, a tube should be carefully carried up and injections of flaxseed-tea be thrown into the bowel. Pain, when severe, must be relieved by opiates, administered either by the mouth or hypodermically. When the bowel becomes seriously blocked up or communications form between the rectum and the bladder, or when the evacuations are attended with intense distress, the surgeon may resort to lumbar colotomy or to excision,—the first for the purpose of securing to the patient an uncertain period of relief from acute suffering, and thus rendering the remainder of life endurable, and the second with some hope of effecting a cure.

In epithelial cancer of the anus the operation of excision is quite as promising as that which follows excision of the lip for a similar disease. When there is severe spasm of the sphincter, in consequence of an extension of rectal cancer downwards to the anus, the muscle should be divided by the knife. When the rectum becomes obstructed with fungoid granulations which bleed profusely, and when it is not deemed proper to excise the diseased part, much relief may be obtained by scraping the granulations away with a scoop, as is often practiced in cancer of the womb. If cleanly done, it not only opens the cavity of the bowel, but also arrests the hemorrhage.

Excision of the Rectum.—The removal of the rectum is a formidable but not a very difficult operation. The success which appears to have followed the excision of this organ by Billroth has recently attracted considerable professional attention. This operator is said to have removed the bowel sixteen times, losing only four patients. Fifty-one years previous (1826) the operation had been executed by Lisfranc, and at a later period by Dieffenbach,—the last-named surgeon having resorted to this procedure, it is said, thirty times. Dr. John B. Roberts, of Philadelphia, has contributed a valuable paper on the subject of excising the rectum.* Of 33 cases collected by Schmidt, of Leipsic,† 20 were reported cured, 2 improved, 8 died, the disease returned in 1, and 2 were doubtful. In this country ten cases have been operated upon,—2 by Busche, 1 by Mott, 1 by Marsh, 1 by Bridden, 3 by Levis, 1 by Dr. Joseph R. Wood, and 1 by myself. Of this number 4 are known to have died, 1 died seven months after the operation, with what was said to be consumption, 1 was living sixteen months after the excision, in 1 the termination is not known, and 3 were cured.

It is impossible to determine the period of immunity from the disease

* "Excision of the Rectum," Medical and Surgical Reporter, June 9, 1877, p. 501.
† Gunther's "Blutigen Operationen," iv. i. p. 65.

enjoyed by those who have submitted to the operation. Dieffenbach says that of the thirty cases of excision of the rectum done by himself a large proportion continued well for many years. Nussbaum, in one case, removed four inches of the rectum, the prostate gland, the corresponding portion of the urethra, and a part of the neck of the bladder,—the patient recovering and living for three years after the operation.* Notwithstanding these and other favorable reports, the return of the disease is the rule; and when the operation is proposed to a patient it should be on the ground of palliation and not of cure. The conditions which, in my judgment, justify the operation are the following: 1, when the disease is epithelial in its character; 2, when it is limited to the walls of the intestine; 3, when there is room to remove the bowel without implicating the peritoneum; and, 4, when the health of the patient is not seriously impaired by the disease. If the cancerous infiltration extends into the ischio-rectal fossa, if the bladder or the uterus is involved, and if the patient is anæmic and very feeble, the operation should not be proposed. The causes of death after excision of the rectum are pyæmia, pelvic cellulitis, and peritonitis.

Operation.—The patient, the bladder having been previously emptied, is to be etherized and to be placed on the back, in the lithotomy position, upon a firm table, an assistant supporting each limb. If a male, a sound should be introduced into the bladder and given to one of the persons having the limbs in charge. The surgeon then carries an incision from the perineal centre along the raphé to the anterior margin of the anus, encircling the latter by two semilunar cuts, and continuing the division directly back to the coccyx. In the female the incision should begin at the vagina. If the anus is not involved in the disease, the external sphincter may be preserved by raising the integument and muscle together and turning them on each side. As soon as the lower extremity of the rectum is reached, the dissection should be chiefly done by the fingers of the surgeon, by the director, or by the handle of the scalpel, keeping close to the bowel, and tying each vessel as it springs. When the intestine has been thoroughly isolated from all its surrounding connections, to a point above the cancerous infiltration, it should be drawn out through the external wound, and the diseased portion severed from the sound. In doing this, only a small part must be divided at one time, and every bleeding artery tied as the surgeon proceeds. This accomplished, double ligatures should be introduced through the bowel from its mucous surface outwards, and afterwards stitched to the integument at the margins of the wound. If the recto-vaginal septum is included in the disease, as was the case in the patient from whom I removed about three inches of the rectum, it will require to be excised, and its sides subsequently united by interrupted sutures. If the operation is conducted after the manner described, very little blood will be lost. The subsequent treatment consists in controlling the bowels by opium for eight or nine days, sustaining the system with milk, milk-punch, and beef-tea, and removing the ligatures as they become loose.

Peri-Anal and Peri-Rectal Abscess.—The peculiar character of the tissues about the anus and rectum—that is, in the ischio-rectal fossa—renders this region liable to attacks of inflammation and of abscess. The connective tissue is loose, supports a large amount of fat, and has ramifying through it numerous branches of the inferior hemorrhoidal arteries and veins, and the inferior hemorrhoidal, the pudic, and the perineal nerves. These veins are without valves, and empty into the portal system. The abscesses of this region are of two kinds, *acute* and *chronic*, and may be subcutaneous, or between the skin and the superficial sphincter muscle, and submuscular, or in the ischio-rectal fossa. The acute abscess arises from constipation, from disorders of the liver which obstruct the venous circulation and favor congestion of the hemorrhoidal veins, and occasionally from local injury. These abscesses run

* Medical and Surgical Reporter, June 9, 1877, p. 501.

their course with rapidity. They appear as a red, tender, painful, indurated swelling at the side of the anus, with a sense of fullness and throbbing in the bowel, accompanied by rigors, fever, an elevated temperature, restlessness, and great suffering both in defecation and in urination. They do not become very prominent externally, but extend deeply into the ischio-rectal space,—a fact which should never be forgotten, and which determines the course of treatment to be pursued.

Treatment.—In the very incipiency of the inflammation, leeches, followed by cold anodyne lotions, may avert the disease; but in most instances the practitioner is consulted too late to hope for this result, and it is better to apply hot poultices in order to favor the formation of pus as soon as possible. The pain is best relieved by some preparation of opium. The surgeon should not wait until fluctuation becomes distinct. A large quantity of pus, as has been stated, may exist without the presence of this sign, and if not early liberated it will produce sad havoc in the structure of the ischio-rectal fossa about the bowel, and even form a fistulous opening into the intestine. As soon as the smallest point of softening can be discovered on the surface, the abscess should be punctured. If the patient is supersensitive or timid, the parts may be sprayed with ether or rhigolene or may be benumbed with ice before the opening is made. If the abscess is not opened early, the contents will become exceedingly offensive, being loaded with sulphuretted hydrogen, broken-down blood, and dead connective tissue. After the matter has been discharged, the poultices should be continued for two or three days, and, if the fetor continues, the cavity of the abscess may be washed out with a solution of permanganate of potash or of chlorinated soda. When the poultices are laid aside, a piece of lint moistened with carbolated oil (one part carbolic acid, twelve parts olive oil) will form the best application.

Chronic abscess.—This abscess may readily escape recognition. It does not commence on the surface. It may originate in the cellular tissue of the ischio-rectal fossa, or it may begin by ulceration of the rectum. In both instances a cellulitis of the peri-rectal or peri-anal regions will be induced,—in the first form by derangement of the venous circulation of the parts, and in the second by air, fæces, and intestinal secretions passing through the ulcer in the walls of the bowel into the surrounding tissues, and causing, like other foreign matters, inflammation. Should the intestinal opening admit only a little air, it may be a long time before an abscess will form. The patient will be annoyed occasionally by a tender and indurated swelling in the vicinity of the anus, which, after a few days, gradually subsides, only to have the experience repeated at no distant day. After this fashion the inflammation extends quietly in different directions through the perineum, and often through the buttock, until a number of concealed sinuses are formed, the pus finding its way into the bowel through the opening in its walls, or, as sometimes occurs, escaping externally by one or more points of ulceration. Should feculent matter extravasate the surrounding cellular tissue, this abscess will assume more the behavior of the acute form, and this is true to some extent when it follows traumatic causes, as blows, kicks, etc. Occurring, as the disease so often does, in persons of a strumous or tubercular constitution, it has been called the strumous abscess, and when its origin is of this nature the pus betokens the constitutional vice by being thin, curdy, and often offensive. These cases generally end in a fistula of the bowel.

Treatment.—When the chronic abscess extends to the surface of the perineum it should be punctured, and its branches, whether one or many, must be carefully followed by a director and freely laid open, after which they may be packed with lint. If a communication with the bowel exists, the treatment will be that appropriate to anal or rectal fistula. In these cases it will often be necessary to direct our remedies to the improvement of the general health, by the use of the iodide of iron, cod-liver oil, and a good diet.

Perineo-Anal and Perineo-Rectal Fistulæ.—These fistulæ are very common.

Though generally an affection of middle life, they are met with, to a limited extent, at all ages. I have seen the disease in a babe six weeks old, and have every reason to believe that it was congenital. It is more common to men than to women, and is generally the result of an abscess, though it may follow a wound. The disease is seen in all classes, conditions, and professions. These fistulæ are divided into *complete* and *incomplete.* A complete perineo-anal or perineo-rectal fistula is one in which there are at least two openings,—one in the anus or rectum and the other upon the surface of the perineum or the buttock. The incomplete form has two varieties,—one, in which there is an opening in the anus or in the rectum but none externally on the surface; the other, in which there is an opening on the surface but none in the anus or in the rectum. These forms are sometimes called "blind fistulæ."

Complete fistula.—In complete fistula the external opening may be single or multiple. Its location varies. Usually it is near to the margin of the anus; but it may be over the coccyx, at the anterior part of the perineum, and even upon the buttock. When there are more external openings than one, they will generally be found to lead to a common canal or sinus. The opening upon the surface appears as a little point of granulation-tissue, or it may be covered with a thin film or cuticle. It is sometimes so small, and differs so little from the surrounding skin, as to be easily overlooked. The internal opening in perineo-anal fistula is at some point between the two sphincters,—sometimes just above the cutaneo-mucous line, but more commonly about half an inch above the orifice of the anus. In the perineo-rectal form the internal opening is above the internal sphincter. In rare instances more than one opening will be found within the bowel. The sinus, or the fistulous canal which unites the external and the internal opening, may consist of a single track, or it may have several branches, all tending to converge to a main road. The fistula may lead directly to the internal opening, or it may follow an angular, tortuous, or circuitous route. It sometimes begins on one side of the anus and passes across the perineum anteriorly to the other before opening into the bowel. This is called the "horseshoe fistula."

Incomplete fistula.—Of the two varieties, the one in which an external opening alone exists is the least common. Many lead down to the side of the rectum or the anus; or they may extend away from the intestine. It is probable that many which are pronounced incomplete would, on a more patient and delicate exploration, be found to be complete. The other variety, that having only an internal opening, is by no means rare, and often exists for months without being suspected. The patient has frequent discharges of a muco-purulent fluid from the bowel; a portion of the contents of the intestine getting into the surrounding cellular tissue provokes inflammatory deposits and abscess in the contiguous structures, which can be detected by the presence of an indurated or hardened point in some part of the perineum. If a speculum be introduced and pressure be made over the indurated part, the pus can be seen flowing into the bowel.

Causes.—It is not always easy to determine the causes of a fistula. Commencing, as it does, in the formation of an abscess, the question arises, What influences are in operation to excite the inflammation which determines the abscess? In some cases the cause is apparent, as when an injury has been received upon the perineum, or when the bowel has been wounded by a fish-bone, a pin, or the scale from an oyster-shell, which has been swallowed and become arrested in the rectum. Dr. Reed has communicated to me the particulars of a case of fistula in a female. The opening was situated on the border of the labium. On laying it open, two grains of corn were found near the rectum. These must have ulcerated through the walls of the bowel. Hardened fæces may damage the mucous membrane and induce an ulceration which will terminate in fistula. Hemorrhoids may produce a similar result, the inflammation extending into the connective tissue exterior to the intestine, and the mucous membrane becoming perforated, as stated by Syme. The connection of fistula with tubercular disease of the lungs has been very

generally noticed, and is regarded by many as a salutary effort on the part of nature to divert disease from the pulmonary organs. I do not believe that any relation, other than an accidental one, exists between the two affections, or that a fistula performs any office of this nature. The explanation of the presence of fistula in pulmonary disease, in my judgment, will be found in the structure of the hemorrhoidal veins and that of the perineum. The former are without valves, and the latter, or the muscular apparatus of which it consists, acts in consonance with the movements of the diaphragm. In coughing, the venous current is forced back upon these defenseless vessels, they become dilated, and the circulation through their channels suffers embarrassment, which eventually excites inflammation, followed by abscess and perforation of the bowel.

Diagnosis.—The diagnosis of fistula may be approximately established by the presence of ulcerated openings or by abscesses in the perineum, which refuse to heal, or, healing for a short time, reopen; by the existence of a hard point without any external orifice, which varies in size at different times and is tender to pressure. The positive existence, however, of fistula can be established by recognizing the escape of flatus or of fæces through the external opening, when such exists, and by making an exploration with the probe. In using this instrument, the patient should be placed upon the side, as directed under the head of preliminary observations. The index finger of the surgeon being introduced into the bowel, the probe should be inserted into the fistulous opening, and by gentle pressure made to follow the abnormal track. No force should be used; otherwise false passages may be made. If the instrument fails to go in one direction, it must be tried in another; it may be used straight or curved, and with a little patience the proper route to the bowel will be found. When the end of the probe is recognized through the walls of the intestine, the finger in the rectum will serve to conduct it through an internal orifice, should such be present in the bowel. When no external opening exists, the necessary information may be gained by introducing a rectal speculum, when, by pressing at different points over the surface of the perineum, the pus may be discovered flowing into the bowel.

Treatment.—The treatment of fistula in ano is palliative and radical. The palliative treatment will be required in cases where there is an indisposition to submit to an operation, or in persons so greatly enfeebled and broken down by other disease that the reparative power of the body is inadequate to the restoration of the parts. Under such circumstances, the bowels are to be regulated, the parts frequently bathed with hot water, and the sinuses injected with a weak solution of the sulphate of zinc or copper (two grains of the salt to the ounce of water), and the friction of the buttocks relieved by smearing over the parts a little oxide of zinc ointment.

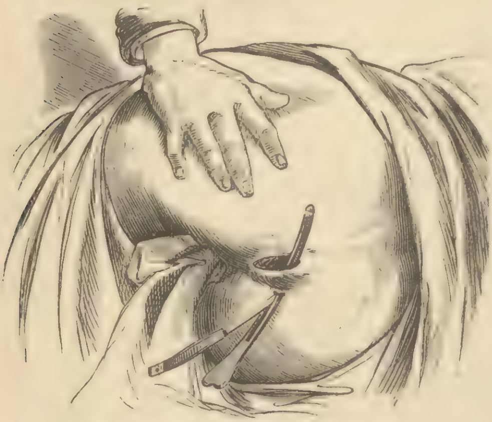
The radical treatment consists in dividing all the structures between the extremities of the sinuses and the surface of the perineum, for which purpose the knife and the seton are employed. I will not deny that a fistula may close through the use of stimulating injections and cauterization; but such a result is exceedingly improbable. Syme narrates the case of Louis XIV., treated by Dionis, who suffered from fistula in ano. So reluctant was his majesty to submit to the knife, that he resorted to every possible expedient to discover some other mode of cure. He sent a number of persons afflicted with the disease to the waters of Barèges, and others to those of Bourbon, and some he placed in rooms, where they were subjected to various remedies. After a year's fruitless experiment, without a single cure, he at last consented to allow M. Felix, his surgeon, to make the cutting operation, the cost of which, when the fees were distributed among the different parties, amounted to the very reasonable sum of fourteen thousand seven hundred pounds sterling.

To effect a cure, it is necessary to place at rest the muscles about the anus and rectum, whose motions would serve, in part, to prevent healing; and also to establish a direct instead of a circuitous communication between the bottom of the fistula and the surface, so that the air, fæces, and muco-puru-

lent discharges shall not be imprisoned, but shall find a ready exit from the tissues. For this purpose the knife is to be preferred, unless the fistula is too high up in the bowel to be safely divided.

Twelve hours before cutting a fistula in ano, the bowels should be cleared out by a gentle cathartic. The patient having been etherized and placed upon the side, with the limbs well drawn up, the surgeon introduces into the fistula a flexible grooved director, which he receives on the extremity of the index finger previously introduced into the intestine, and hooks it forward, bringing it out of the anus. A curved, sharp-pointed bistoury is next introduced into the groove of the director, and all the overlying structures are divided. (Fig. 285.) Should no opening into the bowel exist, it is necessary to make one, which is best done by giving to the director a rotary motion while counter-pressure is made by the finger within, at the point where the two are separated by the thinnest layer of tissue. A careful search must now be made for any other fistulous tracks which may be present, and, if such be discovered, each must be laid open upon the director, from end to end. In case the sides of such sinuses close over the wound, and their edges be thick and purple, it is better to cut them away with a pair of scissors or a knife. When the fistulous canal extends above the point where the internal opening is situated, it must be followed to its termination and the incision in the bowel be made at that place. Some think this is not necessary; that if the parts be divided as deep as the point of communication with the cavity of the bowel, that is all that will be required. This is certainly erroneous, or, at least, has not been verified in my experience.

Fig. 285.



Division of the structures in a fistula in ano.

When no external opening exists, the surgeon must feel for an indurated point, which usually can be discovered upon making firm pressure over the perineum, and upon this he should cut, after which, if the director be inserted in the wound, it will enter the fistula and pass into the intestine. The end of the instrument being drawn through the anus with the finger, the incision of the raised parts should be made as in the complete variety.

The parts being properly laid open, the next indication is to prevent their immediate union, for which purpose the wound should be packed with oiled lint, and, to prevent displacement, a compress should be laid over the perineum and made secure by a T bandage. If the wound is not too deep, I am in the habit, after the first free bleeding is over, of drawing through it a stick of caustic potassa, and afterwards applying the oiled lint. This will produce a superficial slough, and it matters not if the packing works out, as the chasm must fill up by granulation-tissue. The bowels should not be moved for three or four days after the operation: to effect this, half a grain of opium morning and evening will usually suffice. After the lapse of this number of days, a gentle laxative will be required, from which time forward regular alvine evacuations are desirable. The parts must be cleansed with warm water and soap, and the lint renewed daily until the wound becomes so shallow that a dressing is no longer required.

It is not often that a serious hemorrhage follows the operation for fistula in ano. A free bleeding takes place at the moment of incision, but in a short time subsides by exposure to the air. If a vessel continues to bleed,

it must be secured by the ligature, or be twisted. If the flow of blood is from the general surface rather than from a particular point, as happens occasionally when tissues are hard from inflammatory infiltration, the wound must be packed with lint, and a compress and a T bandage applied. The possibility of internal bleeding must not be overlooked; and should the patient experience a sense of fullness in the bowel, become sick at the stomach, and grow pale, with a failing pulse, such hemorrhage may be suspected, whereupon the dressing should be removed and the rectum dilated with a fenestrated speculum, in order to admit the air or pieces of ice, and also to compress the parts.

When the fistula extends so far up the bowel as to render a cutting operation hazardous, the seton may be substituted for the knife, by which means the work of division will be done slowly but not less surely than by the bistoury. To introduce a seton, an eyed probe should be armed with two or three threads of silk, or with a piece of gum cord. Introducing the point of the probe into the fistula and carrying it forward into the bowel, it is to be received by the finger in the intestine and drawn out through the anus, where it must be disengaged from the cord, leaving the latter in the abnormal track with one end hanging from the external opening of the fistula and the other from the anus. If silk thread is used, the ends are best secured by being passed through the holes in an ordinary bone button and tied, gently tightening them every three or four days until the included structures are divided. When the elastic cord is employed, the ends can be tied directly together. The latter is in many respects preferable to silk, as a seton, in this locality. When the cords have ulcerated their way through, the resulting track should be kept packed with oiled lint.

The question will often arise as to the propriety of operating upon fistulæ in persons suffering from tubercular disease of the lungs. Believing, as I do, that such sores have no safety-valve or derivative office by which disease is attracted from the pulmonary organs, I have no hesitation in recommending that they be cured as quickly as possible. They do harm by the drain which they effect from the system, and they annoy and distress the patient from a sense of personal uncleanliness. Before, however, undertaking such an operation in a tubercular subject, the surgeon must have reasonable ground for believing that the health of his patient is sufficient to insure the reparation of the wound. If there is ground for grave doubts on the subject, it is better to abstain from using the knife, as the wound will remain an open one, or perhaps assume a sloughing condition.

Hemorrhoids.

Hemorrhoids, commonly termed piles, are fibrous or vascular growths, situated, the first below, and the second above, the sphincter ani muscle. They are divided into *external* and *internal* hemorrhoids. In either variety of the disease the initial step in their formation is a disorder of the blood-vessels, especially of the hemorrhoidal veins. Immediately above the internal sphincter is an intricate plexus, formed by the radicles of the hemorrhoidal and pudic veins. Those on the sides of the anus terminate in the plexus. Some of the trunks emanating from the latter empty into the mesenteric, and some into the internal iliac veins, so that around the lower end of the rectum the general venous and portal systems commingle.

External Hemorrhoids.—These are situated at the verge of the anus, and appear as pendulous folds of hypertrophied skin. They frequently become inflamed, swollen, and excessively tender, and are generally associated with internal piles. They may be single or multiple, and vary in size from that of a buckshot to that of a walnut. As these tumors have two surfaces—a cutaneous and a mucous—their color will not be uniform. Over the part covered by the skin it will be much like that of the surrounding integuments; and

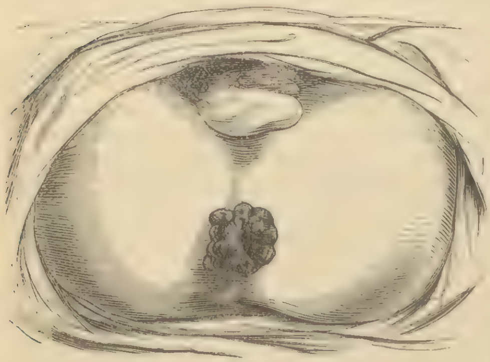
over that covered by the mucous membrane it will be purple, in consequence of the veins being visible through the surface of the latter.

The vascularity of external piles diminishes in proportion to the length of time for which they have existed. They become gradually transformed into fibrous masses by hypertrophy of the submucous and subcutaneous connective tissue. In the formation of external piles, the hemorrhoidal veins become dilated and tortuous; being destitute of valves, they are prone to this change, and, as they lie beneath the sphincter, the varicose condition must manifest itself either above or below this muscle. When an external pile is examined in the commencement of its growth, it is quite soft in consistence, and has a deep purple color. If cut into at this stage, there will follow a profuse flow of blood, chiefly venous. Exposed as it is to influences which tend to excite inflammation, the convolutions of the veins become matted together by plastic deposits, either obliterating their canals or distending their walls to the point of rupture, in either case producing coagulation of the contained blood. While these changes are in progress, the connective tissue increases and the vascular channels diminish. If a section be now made of the tumor, there will probably be found a clot of blood surrounded by a dilated vein or lying in the midst of dense connective tissue. Finally, if a still later period be selected for dissecting the tumor, it will be found to consist wholly of connective tissue.

Internal Hemorrhoids.—Internal piles are situated from half an inch to two and a half inches above the internal sphincter muscle. They are round, oval, and cylindrical in form. They are sometimes scattered at irregular distances over the surface of the bowel, and at other times are clustered together in groups (Fig. 286); their attachment may be broad or narrow, and occasionally is double, forming a considerable intermediate loop. They are invested entirely by mucous membrane, the surface of which may be villous, granular, or smooth, and the color is commonly dark red, becoming purple when prolapsed and constricted by the sphincter. In consistence, internal piles are soft and spongy, much resembling an erectile growth. They are sometimes spoken of as *open* and *blind*, according as they do or do not bleed. These terms express no distinctive characteristics in the tumors, and might without disadvantage be abandoned.

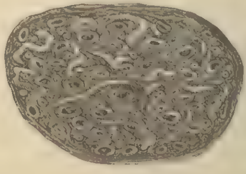
The structure of internal hemorrhoids may be very well studied by inserting pipes into the inferior mesenteric vessels and distending them well with a tallow injection, the latter being afterwards dissolved out. After making sections of the tumors, the interior presents a cavernous appearance (Fig.

FIG. 286.



A group of prolapsed hemorrhoids.

FIG. 287.



Section of an internal hemorrhoid.

287), and consists of tortuous and dilated veins and arteries, the former predominating. The vessels are connected by straggling threads of fibrous tissue, and the whole growth is covered with mucous membrane. There is

another variety of piles which consists of cylindrical elongations of limited portions of the normal columns of the rectum. They are very vascular, abounding in small arterial branches, and are of a bright scarlet color. The anatomical difference between this and the former variety of hemorrhoids is the absence of any great dilatation of the vessels in the latter.

Causes.—The hemorrhoidal veins, as has been stated, form a very intricate plexus beneath the internal sphincter muscle. These vessels are destitute of valves, and the blood which circulates through their channels is carried back to the heart chiefly through the mesenteric veins, which terminate in the vena porta. Whatever tends to favor an undue accumulation of blood in the hemorrhoidal plexus predisposes to piles. For this reason they frequently follow diseases of the liver, which cause obstruction to the portal circulation. The mechanical pressure of abdominal tumors, and that from the gravid uterus, are frequent causes of the disease, by keeping the rectal veins over-distended. Diseases which provoke much straining, as stricture of the urethra, enlargement of the prostate, and stone in the bladder, are also actively concerned in the production of piles. The most common cause, however, is constipation.

They are met with in all classes, though oftener occurring in persons of indolent, sedentary, and luxurious habits of life. No age is exempt from the disease. They are seen at all periods of life, from early infancy to extreme old age. Nor are piles peculiar to either sex, males and females suffering with equal frequency. They are often associated with fissure, fistula, and cancer of the ano-rectal region.

Symptoms.—When the disease is slight, or when the tumors are just beginning to form, only a slight uneasiness may be experienced, such as a little soreness, heat, or itching at the verge of the anus. These sensations are aggravated if the bowels remain costive. If there are external piles, they frequently become inflamed, swollen, and painful, and in some instances suppurate, which usually results in their cure. When internal piles have increased to any considerable extent, or have become inflamed, they produce not only the symptoms of heat and itching at the extremity of the bowel, but also a sense of fullness in the rectum, as though some foreign body were present; there is a feeling also, after defecation, as though a portion of the fæces still remained. When the hemorrhoids become large, they frequently descend along with the evacuation and protrude externally, being covered with a profuse mucous secretion, and if the sphincter is firm, their color becomes deep purple in consequence of the muscular constriction to which they are subjected. Sometimes, after prolapsus, they recede spontaneously within the bowel; at other times it is necessary for the patient to press them back with the hand. In some instances the protrusion is constant, and may consist of one or more piles lying in the centre of the anal orifice, or they may project around its entire circumference. The last condition is frequently confounded with œdema of the mucous membrane, which forms a thick and swollen ring about the anus, but which, unlike hemorrhoids, is smooth and uniform instead of being indented and lobular. Frequently, during hemorrhoidal protrusion, some vessels give way, followed by a free escape of arterial blood, in consequence of the constriction of the sphincter muscle. Or the flow may be caused by excoriation or by ulceration. The quantity of blood lost varies in different cases: it may be only a teaspoonful, or it may amount to several ounces. This discharge, repeated at each succeeding passage from the bowels, soon begins to make a very decided impression upon the system. The patient loses flesh and strength, the face becomes pale, anæmic, and puffy, and finally assumes a waxy color, and vertigo and nausea are often present. In some cases, in consequence of relaxation of the sphincter, the piles remain permanently prolapsed, or they may descend when the patient is long on his feet, or when he makes some considerable muscular effort, especially in the stooping posture.

The *diagnosis* of hemorrhoids is not difficult, and is most satisfactorily de-

termined by requiring the patient to sit over a vessel containing hot water and strain the tumors down outside of the anus. Their irregular ovoidal form, broad attachment to the intestine, red or purple color, and the absence of any very acute suffering sufficiently declare their nature.

The symptoms of hemorrhoids should never be confounded with those of fissure of the anus; although the mistake is frequently made.

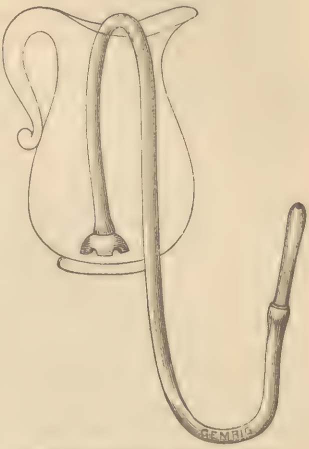
Treatment.—When external piles become inflamed, they often cause severe suffering. Under such circumstances it is best for the patient for a few days to remain in the recumbent position, in order to take off the blood-pressure from the anus, and at the same time to cover the parts with a cold lotion of lead-water and laudanum. If the pain is very severe, a few punctures should be made into the swollen pile with a needle; or, what is still more effective, a free incision should be made into its substance, unloading the distended veins, or perhaps turning out a central clot of blood. Though it is generally advised to apply remedies cold to these tumors, I have often found that hot applications afforded relief when the others did not. In this particular the sensations of the patient should be consulted, and the temperature regulated accordingly. When external piles become the subjects of frequent inflammatory attacks, they should be clipped off; but never during the inflamed condition. The operation is very simple, and consists in raising the tumors by a tenaculum or forceps and cutting them off at the base with a pair of scissors. If a vessel springs, it should be embraced by a ligature.

The treatment of internal piles is *palliative* and *radical.*

Palliative Treatment.—Very much may be done in this way to render the patient comfortable. The diet must be carefully regulated, all highly-seasoned or over-stimulating food being avoided, and stimulants of every kind forbidden. If the bowels are constipated, it is of the first importance to correct this condition, either by the use of stewed fruits, oatmeal porridge, or cornmeal mush with molasses, or, if these articles prove insufficient for this object, by taking at bedtime a teaspoonful of a powder consisting of equal parts of sulphur and cream of tartar mixed with a little syrup. The addition of a portion of the confection of senna to this powder will make it somewhat more active as a laxative, and may be employed with advantage when the bowels are very sluggish. A single teaspoonful of the sulphate of soda, taken in a tumbler of water three-quarters of an hour before breakfast, will procure a satisfactory movement, and appears to act specifically upon the portal vessels. The use of cold-water injections, so much extolled by most writers, certainly exercises a salutary influence, by unloading the rectum and allaying local irritation; but their habitual use I am confident does harm, by creating a torpor or inertia of the lower bowel, so that their repetition becomes more and more necessary. For this reason I have for some time discouraged the use of enemata. When much internal soreness and irritation are experienced in the hemorrhoids, a small enema, consisting of one ounce of lime-water with a teaspoonful of linseed oil, will give great comfort. This should be administered after the bowels are opened, and to retain it permanently the patient should lie down for fifteen or twenty minutes, until the disposition to expel it has passed over. A saturated solution of the chlorate of potash, used as an enema, in the same quantity as the lime-water, will also prove a valuable remedy. These local applications, when they do not effect the desired end, may be materially assisted by the use of copaiba. A capsule containing twenty drops may be taken four or five times a day. Sir Benjamin Brodie employed this remedy in conjunction with the liquor potassæ. Fifteen drops of the latter, with half a drachm of the former, rubbed up with mucilage and cinnamon-water, were given three times a day. The combination, when the stomach will receive it kindly, is among the best of internal remedies. A confection of pepper, known as Ward's paste, was at one time quite popular with British surgeons. Sir Everard Home was in the habit of applying it locally, having been led to this practice by a patient who, instead of taking the paste by the mouth, pushed

a quantity up the rectum, with the effect of curing his hemorrhoids. When the piles protrude during defecation, they should be immediately pressed within the sphincter: otherwise the constriction of the sphincter, acting like a cord and preventing the return of the blood, will cause the tumors to become so swollen as to render their replacement a task of much difficulty. To restore incarcerated piles, the patient, if a male, should be placed upon the elbows or knees, the pelvis being well elevated; if a female, upon the side, with a pillow slipped under the hips. The fingers of the surgeon, being well oiled, should grasp the piles, and, by gradually squeezing them, press out the blood, when they will readily recede. Should this manipulation not succeed, it is best to etherize the patient, and, by dilating the sphincter, to remove at once all obstacle to their reduction. When the hemorrhoids have a tendency to prolapse during the act of standing or of walking, or from weakness of the sphincter muscle, cold water applied to the anus and perineum, in the form of a fine stream, immediately after defecation, will act as a powerful tonic to the muscular structures of the ano-rectal region, and, as I have frequently seen, will render them sufficiently vigorous to prevent protrusion. The instrument which I direct for applying the cold water is a gum hose, five or six feet long, at one end of which is attached a bell-shaped expansion of metal, and at the other a bone nozzle. (Fig. 288.) After filling the hose, the bell-mouth is dropped into a basin of water elevated some distance above the head of the patient, and the stream permitted to flow from the nozzle against the perineum and anus with considerable force, using for each lavement at least one gallon of cold water. This should always be used immediately after a stool. There is something peculiar in the action of a fine stream of water: it produces a much more energetic contraction of muscular fibre than that caused by bathing or sponging. A bidet is also convenient. In obstinate cases of prolapse, relief may often be obtained by introducing, after the replacement of the piles, a rectal obturator. (Fig. 289.) If the obturator cannot be worn, relief may be secured by using a hemorrhoidal truss. This apparatus consists of a horizontal band supporting a steel spring, at the free extremity of which is an oval ivory pad with two perineal straps. (Fig. 290.) In applying the instrument, the band is buckled round the pelvis, the steel rod passed between the nates, with the ivory pad resting against the verge of the anus, and the perineal straps made fast to the front of the horizontal band. Persons who suffer from prolapse of hemorrhoids should avoid cushioned chairs, using rather those with cane seats. They should not sit down during defecation, as in this position the parts about the perineum are spread open so as to favor the displacement of the tumors. The evacuation is best accomplished when semi-erect, and by

FIG. 288.

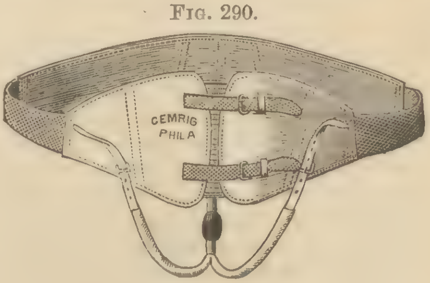


Hose for irrigating hemorrhoids.

FIG. 289.

Rectal obturator for retaining piles.

FIG. 290.



Hemorrhoidal truss.

voluntarily contracting the sphincter the passage should be "wire-drawn,"—that is, strained through the anal aperture with the least possible dilatation of the sphincter ani muscle. Immediately after stool the patient ought to lie down for fifteen or twenty minutes, until the engorged veins of the rectum are emptied and the parts are contracted down to their former condition. It is always desirable for those suffering from hemorrhoids to establish the habit of going to stool before retiring to bed, as they will obtain the fullest benefit from recumbency. A little attention to the above directions, carried out systematically and persistently, will contribute immensely to the comfort of those who are affected with hemorrhoids, and in many instances will effect a cure.

Radical Treatment.—The radical cure of piles consists in their removal. There are four methods of accomplishing this, viz., by strangulation, by the cautery, by the écraseur, and by caustics. Strangulation and the cautery are the plans to be preferred. The operation by the écraseur is not unattended with danger from hemorrhage, and, from including a large amount of mucous membrane, sometimes produces cicatricial contraction of the rectum. Caustics are slow and often painful. I have not alluded to excision by the knife, as such an operation would be rash and unjustifiable.

Operation by Ligature.—This plan is almost entirely devoid of danger, and is executed either by ligature or by the double canula and wire. The ligature is to be preferred. The patient's bowels should be well opened the day previous to the operation, after which an opiate should be administered consisting of one grain of opium. In order to protrude the tumors, the patient should be directed to sit over a vessel containing hot water, the vapor of which serves to attract an increased amount of blood to the hemorrhoidal veins, thereby enlarging the tumors and at the same time removing the resistance of the sphincter. A little straining while in this position will cause the piles to descend. A large injection of warm water thrown into the rectum will, when expelled, effect the same end; or they may be hooked down by the finger. In the female, this may be done by acting through the vagina. The next step is the etherization of the patient, as the operation is one attended with severe pain. This done, each pile, or, if not too large, a group of two or three piles, should be transfixed with either a single or a double tenaculum, drawn well out, and a long ligature of strong hempen thread passed through their base by means of a needle supported on a handle. (Fig.

Fig. 291.

Needle armed with a thread previously to passing it through the base of a pile.

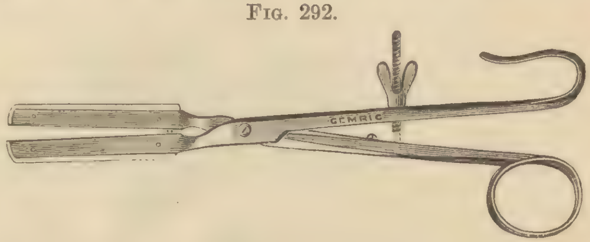
291.) The thread being cut, and disengaged from the eye of the needle, the latter is withdrawn, by which a double ligature is formed. A slight incision through the skin, a little beyond its junction with the mucous membrane, should now be made, as suggested by Horner, after which, the pile being well drawn down, the thread should be tied firmly in a single knot, the outer one occupying the groove cut in the integument. The tenaculum should now be removed, and each ligature drawn upon with additional force before making the second knot. The object of incising the skin for the external ligature is to save pain, to hasten the separation of the included mass, and to render the cure more certain by the consequent cicatricial contraction; the design in not making the second knot until after the tenaculum is removed, is to provide for the shrinkage which follows the escape of blood, and to enable the operator to make the strangulation complete. The value of having each ligature long will be appreciated when they are being drawn upon previously to making the second knot, as the ends can be wrapped

round the hand and much force exerted in making them tight. If the tumors have been properly secured, in a little time they will become blue, showing that their circulation has been completely arrested. The ligatures may now be cut off near to the knots, and the strangulated masses returned into the bowel, after which a small enema, consisting of two tablespoonfuls of starch-water with forty-five drops of laudanum, should be thrown into the rectum. The after-treatment consists in confining the patient to bed, keeping the bowels quiet by the use of a grain of opium daily, and directing for the first four or five days a liquid diet, after which solid food may be allowed. If the pain following the operation proves severe, anodynes must be given to the extent of securing relief. In most cases the patient will be unable—at least for a few days—to pass the urine, and will require the use of the catheter twice or three times in the twenty-four hours. In the course of seven or eight days a gentle laxative should be given, when the loops of the ligatures will generally be passed in the stool, and two days following this event the patient may be allowed to rise and go about. Frequently during the treatment patients suffer from spasmodic contraction of the levator ani muscles and flatulent distention of the abdomen. Opium is the best remedy for both of these conditions. The odor which emanates from the discharges about the anus, caused by the decomposing piles, is best corrected by frequent ablutions with carbolic acid soap and water, or by bathing with dilute bromo-chloralum. To allay the extreme external tenderness of which some patients complain, nothing proves more soothing than a free application to the parts of cocoa-butter melted with the benzoated oxide of zinc ointment.

This operation is simple, safe, and efficient; indeed, it may be said to be almost free from danger. I have never witnessed in a single instance any alarming symptoms follow the use of the ligature. Cases are recorded in which patients have perished after the ligation of hemorrhoids, from erysipelas, from pyæmia, and from tetanus; but such terminations are very uncommon. Allingham states that of three thousand two hundred and thirteen operations for piles at St. Mark's Hospital, there have been only five cases of tetanus, and not one of pyæmia.

Next to the ligature, strangulation and removal by the clamp and cautery is to be preferred, provided the piles are small. This operation was introduced by Mr. Cusack, of Dublin, Ireland. The instrument best adapted for the purpose is the clamp of Mr. H. Smith, of London. It consists of two blades, one of which is grooved, the other serrated. To the back of each blade is screwed a piece of ivory, designed to protect the skin from the heat of cautery. The blades have a screw by which they can be firmly brought together. (Fig. 292.) A knife, a pair of forceps, and a cauterizing-iron (Fig. 293) complete the apparatus.

FIG. 292.



Smith's clamp for piles.

FIG. 293.

Cautery.

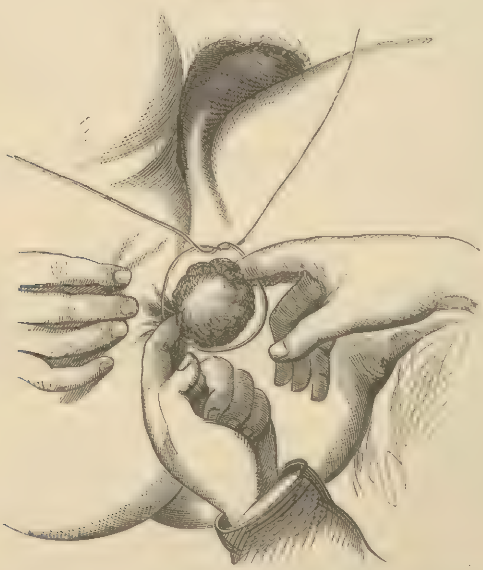
OPERATION BY THE CLAMP.—The patient being etherized, the pile is drawn down and embraced by the clamp close to its attachment with the bowel. The screw is next run down so as to strangulate effectually the pedicle, when the mass in front of the instrument is cut off, either with the knife or scissors, leaving a stump about three-eighths of an inch long.

This is next thoroughly seared or cauterized with the hot iron, after which the blades are unscrewed and the clamp is removed. The patient should be confined to bed after this operation for five or six days, and the bowels kept quiet with an opiate; after this a laxative should be given, when the case may be considered cured.

Treatment by Caustics.—There are persons who, from timidity, are unwilling to submit to either the ligature or the clamp, and for whom something must be done for relief, especially when the tumors bleed freely. In such cases the surgeon may resort to caustics. Nitric acid has been extolled by Mr. Houston, of Dublin, and others. As a means of arresting the capillary oozing of blood in soft vascular piles it will sometimes be found a valuable remedy. The acid is best applied through a fenestrated speculum, with a piece of pine wood, taking care that the redundant liquid is removed by means of a dossil of cotton or lint, and that the surrounding parts are well protected, and afterwards smeared with olive oil. The effect of the acid is to produce a granulating surface, the contraction of which after cicatrization may temporarily arrest the growth of the pile, and may sometimes effect a cure. Chloride of zinc has been used as an application to hemorrhoids. It produces a deep slough, which results in the cure of the piles, but requires too much care in its application to warrant its general use.

Removal by the Écraseur.—Chassaignac employed the écraseur for the removal of hemorrhoidal tumors, and there are a few American surgeons who still prefer this instrument. I have known instances in which patients came near losing their lives from hemorrhage after its employment, and in consequence I have long ceased to use it. The method of Chassaignac was

Fig. 294.

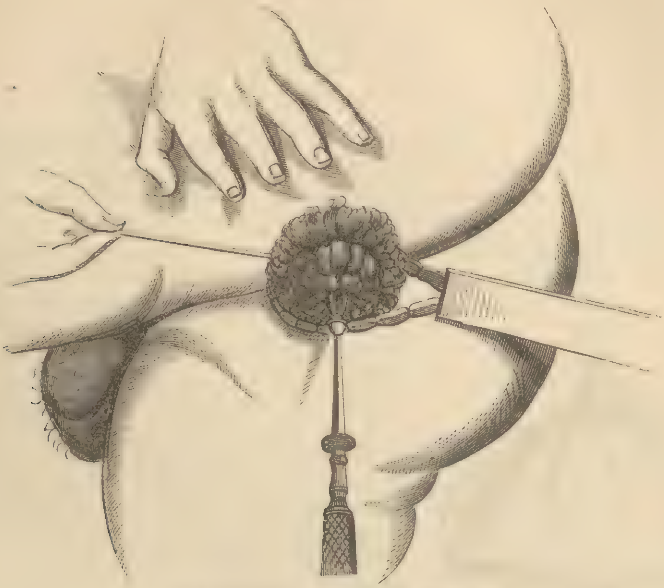


Ligature applied in order to narrow the base of the hemorrhoidal mass previous to applying the écraseur.—After Chassaignac.

first to pedunculate the tumors, by carrying over them a loop of strong thread, introduced into the rectum around the finger, and, after hooking down the piles with the latter, getting an assistant to tighten the ligature firmly about the base of the tumor. (Fig. 294.) The chain of the écraseur was next passed over the hemorrhoids close up to the cord, and, while the mass was held by a tenaculum (Fig. 295), it was slowly crushed off by the

movements of the lever of the instrument. When the écraseur is used, a much simpler method is to drag down the tumors and pass a long needle or

Fig. 295.



The écraseur applied.—After Chassaignac.

pin across their base, then to slip the chain over the hemorrhoids down to the pin, and, by slowly turning the handle of the instrument, cut them off, taking twenty or twenty-five minutes for accomplishing the work.

Complications.—Though a very uncommon occurrence, yet bleeding may follow the separation of the ligatures, especially in cases where the hemorrhoids have been partially disorganized. The resistance offered by the sphincter will prevent the blood from escaping externally, and a dangerous concealed hemorrhage may take place without being suspected. Patients generally, in this kind of internal bleeding, are conscious of something trickling away, and will so express themselves. When a large amount of blood is lost, they become pale, sick at the stomach, and cold, while the pulse is feeble and frequent, and the surface is covered by a clammy sweat. Whenever hemorrhage exists, a careful examination of the bowel should be immediately instituted. It may proceed from a single vessel, or from a very limited surface of the mucous membrane, and be controllable at once by a ligature. If the part from which the blood issues be too extensive for inclusion by the ordinary ligature, an acupressure-pin should be pushed beneath the bleeding surface and a wire or silk thread thrown about it. If these measures prove insufficient, it is advisable to proceed at once to tampon the rectum. A number of ingenious suggestions and contrivances have been made for this purpose, but none are more reliable than the sponge of Allingham, or the rectal chemise which I have had made. The first consists of a soft conical or bell-shaped sponge, with a loop of strong silk or hempen thread passed through its summit, the two ends of the thread hanging below. The sponge, having been soaked in water and afterwards squeezed dry, is to have its pores well powdered with persulphate of iron or with alum, and then to be pushed on the end of the finger or by a bougie through the anus and four inches or more up the bowel. This accomplished, the rectum is next to be stuffed with charpie or cotton wool well dusted with persulphate of iron or with

alum, after which, by pulling upon the thread with one hand and at the same time pushing up the cotton wool or charpie with the other, the sponge is both drawn down and spread out, so as to press accurately on all sides against the inner surface of the rectum. To allow the passage of flatus, which is frequently a troublesome and painful attendant of operations upon the rectum, a flexible catheter may be passed through the summit of the sponge before packing the bowel, or it may be introduced between the latter and the tampon. This tampon should be allowed to remain for eight or ten days before it is removed, preliminary to which the packing must be picked out from the cavity of the sponge.

The rectal chemise, which fulfills the same end as the sponge of Allingham, is prepared as follows. Through the openings at the end of the largest-sized gum catheter pass a strong silk thread; take three square pieces of the material usually known as mosquito-netting, place them one on top of the other; at the centre of these squares or pieces make an opening, and pass the catheter through it, securing the two together by the threads. (Fig. 296.) In applying the instrument, the different layers of the chemise must be moistened with water, and afterwards well filled with the persulphate of iron. It is then conducted some distance into the rectum on a finger previously inserted; after which it is expanded like a parachute by packing between the catheter and its hood, with long strips of lint thrust up on the end of a bougie, until the bowel is distended on every side. The catheter will serve to conduct away the flatus; and when, after eight or ten days, its removal becomes necessary, this is very easily effected by drawing out the ribbon-like pieces of lint which were used as packing.

Fig. 296.

Author's rectal chemise.

In cases where hemorrhoids are complicated with polypus, fistula in ano, stricture, or uterine displacements, the cure of the latter is necessary to the success of any operation upon the former.

When hemorrhoids are the result of organic disease of the liver, permanently obstructing the circulation through the portal veins, or when they arise from the pressure of abdominal tumors or of the gravid uterus, no operation is proper, for unless the cause be removed the disease will certainly return.

HERNIA.

Hernia, in the widest acceptation of the term, is the protrusion of any organ or structure through a natural or preternatural opening. Thus, we speak of hernia of the brain, of the iris, of the bladder, etc. In the more restricted and proper sense, it is the protrusion of an intestine, of omentum, or of both, from the interior to the exterior of the abdominal cavity, in the course of certain blood-vessels. The abdominal walls, for the most part, are admirably constructed to prevent visceral protrusions. They consist of stratifications of muscular and aponeurotic tissues, the fibres of which are disposed in different directions. The external oblique muscles run from above downwards; the internal oblique, from below upwards; the transversalis, transversely; and the recti, with their tendinous intersections and sheaths of strong fibrous tissue, extend perpendicularly between the pelvis and thorax. There are, however, certain points in the parietes which are necessarily less capable of resisting pressure from within than others; and these points correspond to where the blood-vessels designed to supply

the outstanding organs leave the body. A knowledge of these vessels is the key to a proper understanding of hernia.

General Division of Hernia.—There are two grand divisions of hernia, *congenital* and *acquired.* Under the first division are included all herniæ that occur before birth; under the second, all that result from weakness of the abdominal parietes or from accident after birth.

Varieties of Hernia.—When a hernia follows the course of the spermatic cord or blood-vessels, it is called a *spermatic* or an *inguinal* hernia; when it takes the direction of the femoral or crural vessels, it constitutes a *femoral* or a *crural* hernia; when its direction is in the course of the umbilical vessels, it is termed an *umbilical* hernia; if in the course of the obturator arteries, it is an *obturator* hernia; if it follows the gluteal or ischiatic vessels, it constitutes a *gluteal* or *ischiatic* hernia. The last three forms are very rare. In addition to these varieties, there are a number of herniæ which do not follow, in all cases, the course of the blood-vessels. They are the *diaphragmatic*, the *pudendal*, the *perineal*, and the *sacro-rectal* herniæ.

Anatomical Components.—The components of a hernia are its *sac*, its *contents*, and its *coverings*.

The *sac* is a serous membrane, and is derived from the parietal layer of the peritoneum. It is pushed before the hernia, gradually forming an elongated pouch. In congenital hernia the sac exists before birth, being formed not by the rupture, but by the descent of the testicle. The failure to close this tubular prolongation by a natural process of contraction, and thus to shut off communication with the common peritoneal cavity, explains the occurrence of a congenital hernia.

Cæcal hernia, when it occurs, is without a complete sac. This is due to the fact that the iliac surface of the bowel is non-peritoneal, and when it passes out of the abdomen to form a hernia the serous layer is detached from its free surface.

Hernial sacs differ greatly in size, form, and appearance. In size, they vary from that of a marble to that of a cocoanut; in form, they may be tubular, pyriform, sacculated (Fig. 297), or spherical; and in appearance, smooth, thin, and translucent, or rough, thick, and opaque from inflammatory changes. The larger and the older the sac, the more does its character differ from that of the serous membrane from which it is derived.

Fig. 297.

Sacculated sac. Pyriform hernial sac. *a*, neck; *b*, mouth; *c*, body; *d*, fundus.

Whatever the form of the sac, it is divided into the neck, fundus, body, and mouth. (Fig. 297.) The neck is the narrow, constricted part produced by the ring through which it passes. The effect of the constriction is to corrugate or plicate this part of the sac. These plications may disappear when the membrane is returned back into the cavity of the abdomen, or they may be glued together by inflammatory lymph and rendered permanent. The fundus is the most dependent portion of the sac; the body is that part between the fundus and the neck; and the mouth is the expanded opening which looks towards the abdominal cavity.

Contents of the sac.—The contents of the sac have formed the basis for certain names which have been given to hernial tumors. Thus, when the sac contains a portion of intestine, it is called an *enterocele;* when it contains omentum, an *epiplocele;* and when both intestine and omentum are present, an *entero-epiplocele.* The terms *cystocele* and *gastrocele* are used to express protrusions of the bladder and of the stomach. Besides the above-named constituents, the sac usually contains a serous fluid, which sometimes

accumulates in large quantities, especially when associated with abdominal dropsy. In rare cases, when a hernia has been cured, the sac may remain open and become filled with a fluid, giving rise to what has been called a *hydrocele* of the sac. Even an epiploic appendix has been known to become detached and find its way into the serous pouch. In enterocele, the ileum is that part of the intestine generally found in the sac, which fact is due to the loose nature of its mesenteric attachments. The amount of intestine which enters the sac varies greatly in different cases. It may not be larger than the end of the finger, or it may consist of several coils. In rare instances the entire small intestine has been seen in the sac. The large intestine is rarely found to form a part of a hernia. When a large portion of the bowel enters the hernial sac and is allowed to remain, it is prone to undergo structural changes, affecting its color, consistence, and functions. Its normal translucence is lost; its structure becomes less polished and less elastic; bands of lymph connect the intestinal loops; and the peristalsis is imperfectly executed. The patient is frequently harassed with flatulence and with colicky pains. In epiplocele, the effect of a long residence in the sac is to produce great thickening of the omentum. In entero-epiplocele, the intestine is sometimes found pushed before the omentum, sometimes entirely surrounded by it, and at other times the two are curiously intertwined. The bowel has in some instances become strangulated, in consequence of being constricted by the omentum. In old cases of entero-epiplocele it is not uncommon to find bands of lymph uniting together portions of the omentum and the intestine, and occasionally both are bound to the interior of the sac.

The *coverings of a hernia* are the different strata of tissues—cutaneous, fascial, aponeurotic, muscular, and serous—which overlie the contents. They are not the same in all forms of hernia.

When a hernia returns spontaneously, or can be restored by manipulation into the cavity of the abdomen, it is called a *reducible hernia*; when the contents of a hernia cannot be thus returned, it is said to be *irreducible;* and when the contents become constricted, so as not only to resist reduction but also to give rise to pain and to vomiting, it is designated a *strangulated* hernia.

Causes.—The causes of hernia are *predisposing* and *exciting*.

Predisposing.—Among the predisposing causes may be enumerated the following:

Muscular weakness of the abdominal parietes.—This is often associated with a large accumulation of fat. This weakness may be produced by wounds; by the atrophy which follows protracted illness; by distention from large accumulations of ascitic fluid, and from pregnancy; and by a variety of other causes, such as coughing, straining, jumping, vomiting, and lifting heavy weights.

Occupation.—The laboring classes, being the most numerous, furnish the largest number of herniæ. Occupations which require much physical effort when the body is in the stooping posture expose most to the disease, as the walls of the abdomen being thus relaxed are less able to resist the pressure of the viscera. The common habit among laborers of girding the loins tends to produce the disease. It has been said that musicians who use wind-instruments are much exposed to rupture. This does not correspond with my observation. Persons following this calling execute their music in the erect position, and during the act of blowing the diaphragm is gradually ascending, allowing the viscera of the abdomen to rise. Gymnasts and contortionists might be supposed to be particularly liable to hernia, yet this class of persons are remarkably free from the disease. Indeed, the more I observe of hernia the less importance do I attach to occupation in the production of the malady.*

Sex.—Males suffer more than females,—the proportion, it is said, being four of the former to one of the latter. This statement is based upon a report of the London Truss Society, in which it appears that out of 96,886 persons apply-

* For statistics, see Medical Statistics of the Provost-Marshal-General's Bureau, War of the Rebellion, pp. 471, 476, *et seq.*

ing for trusses only 18,492 were females. I find, on inquiry at the different truss- and instrument-makers' establishments in Philadelphia, that those who purchase trusses are for the most part males. That this sex should be more liable to hernia than the feminine, might be anticipated from the different character of their employments: yet I think the difference is over-estimated. Females are less disposed than males to seek relief for such affections, and I am quite certain that if the comparison is made in private practice the disproportion will not be so great as it is usually represented. Males are said to be most liable to inguinal, females to femoral and umbilical herniæ. With reference to females, age exercises a modifying influence in this respect. Under twenty years, they are more liable to inguinal than to femoral hernia; but during the middle period of life—*i.e.*, between twenty-five and forty-five years —femoral is much the more common form. The explanation of the above facts must be sought for in certain anatomical peculiarities. In young females the canal of Nuck formed by the round ligament with its processus vaginalis, not being easily closed, invites an inguinal protrusion, whereas the superior development of the pelvis, in obedience to the function of child-bearing, in maturer years renders the crural arch less able to resist visceral pressure than before, and hence the frequency of the femoral variety. The proportion of cases of hernia to the entire population of a country is materially influenced by climate and the prevailing industries. Heat and toil are important factors in determining the ratio. In France, according to Malgaigne, one man in every thirteen, and one woman in every fifty-two, suffer from hernia. In the United States, one out of fifteen would not be too high an estimate. I have ascertained from Dr. Abel, one of the resident physicians of the Philadelphia Almshouse, who, at my request, collected some materials relating to the subject of hernia, that there are annually in the male and female outwards of the above institution twelve hundred people, and that of this number about ten per cent. suffer from different forms of this defect.

Age.—In infants, congenital and acquired herniæ are very common during the first year of life,—estimated by Malgaigne at one case in every twenty-one children. It is during this period that children are harassed with intestinal irritations, causing fretting, crying, and straining,—all of which favor the production of the disease. If, however, we take into consideration the large number of children as compared with adolescent and adult individuals, the frequency of the disease in the former may not be greater than in the latter. From the first to the thirteenth year the disease steadily diminishes in frequency, after which it again increases to old age. In an analysis of 77,997 cases of hernia by the London Truss Society, the largest number of cases (15,627) occurred between forty and fifty. In the 334,321 recruits who formed the subjects of the Reports of the Provost-Marshal-General,* the largest number of cases was found in men over forty years of age, amounting to a ratio of ninety-one per thousand.

Congenital defects of development.—Under this head may be enumerated muscular or tendinous deficiency at the lower part of the abdomen. It is from this cause that in exstrophy of the bladder it is common to have double hernia. There is also, in some instances, a transmitted weakness of the muscular and the aponeurotic structures in the neighborhood of the groin, in consequence of which several members of a family may suffer from intestinal protrusions. Again, the funicular process of the peritoneum may not close at the internal ring, thereby leaving the inguinal canal open, and inviting the descent of a hernia.

An elongated state of the mesentery is alleged by Mr. Birkett to be another predisposing cause. This elongation, I am disposed to believe, is not antecedent to the hernial protrusion, but subsequent to it.

Nativity.—In scrutinizing the nativity of 501,068 persons examined during the War of the Rebellion,† the ratio per one thousand among foreigners

* Medical Statistics of the Provost-Marshal-General's Bureau, War of the Rebellion.
† Ibid., Chart XIV.

rejected for hernia is found to differ very greatly, while in those from the different parts of the United States the difference is very slight indeed. By glancing at the subjoined table* these facts will be readily observed:

HERNIA.

Nativity.	Number examined.	Ratio rejected per 1000.	Locality.	Number examined.	Ratio rejected per 1000.
All nativities	501,068	44	All States	501,002	31
Portugal	81	123	Minnesota	6,489	54
Spain	148	114	Vermont	7,224	43
Hungary	89	89	Iowa	6,846	41
Mexico	91	87	Wisconsin	21,945	40
Germany	54,944	82	Illinois	18,126	38
Italy	339	76	Missouri	8,576	36
Switzerland	1,802	68	Maryland	16,920	34
Holland	989	65	Michigan	12,179	33
France	3,243	65	New York	95,576	32
Poland	171	64	Maine	20,479	31
Denmark	333	62	Indiana	29,279	31
Sweden	1,190	55	District of Columbia	6,954	30
Wales	1,104	52	Kentucky	16,028	29
Russia	122	49	Pennsylvania	12,686	29
Norway	2,290	48	New Hampshire	10,013	27
United States (white)	315,620	39	Ohio	37,700	27
West Indies	580	39	New Jersey	15,388	27
England	16,196	39	Massachusetts	36,380	26
United States (colored)	25,828	38	Connecticut	11,017	26
Ireland	50,537	36	Delaware	6,361	26
Scotland	3,476	34	Rhode Island	4,072	24
British America	21,645	31	West Virginia	764	20
South America	79	25			
United States Indians	121	0			

In the above list of nativities the most remarkable feature is the frequency of hernia among the German recruits. Comparing the number of this people examined (54,944) with the Irish (50,537), the difference will be seen to be 46, the ratio being 82 for the former and 36 for the latter. The number of the two nationalities being so nearly equal, the comparison may be regarded as just. I can conceive of no explanation for the disparity, unless it be that the extensive use of beer among the German population causes fatty degeneration in the muscular walls of the abdomen, and thus predisposes them to hernial protrusions.

EXCITING CAUSE.—The exciting cause of hernia is muscular action, by which, in certain postures of the body, the viscera are forcibly thrust against the lower portion of the abdomen, which yields at those points naturally weakened by the passage of blood-vessels.

MANNER OF OCCURRENCE.—Sometimes when a person is making an extraordinary muscular effort, or when an accident occurs in which an individual is thrown forcibly from a vehicle, the protrusion may be the work of an instant; but these are exceptional cases, the usual process being a gradual and slow one, requiring several months before the swelling has attained sufficient bulk or importance to attract attention particularly.

RELATIVE FREQUENCY OF THE DIFFERENT FORMS OF HERNIA.—Inguinal hernia is much the most common form of the disease. Of 411 cases of hernia collected by Dr. Abel from the records of the Philadelphia Hospital, 377 were inguinal, seven of the number being double, or on each side. Next in order of frequency is femoral hernia; and last, umbilical. Taking a large number of cases of hernia as a basis for estimating the relative ratio of the different kinds, 75 per cent. will be found to be inguinal, 10 per cent. femoral, and 5 per cent. umbilical. Inguinal hernia is most common on the right side.

Of 334,321 recruits, substitutes, drafted and enrolled men of various nativities examined during the late American war, there were 17,296 rejected

* Medical Statistics of the Provost-Marshal-General's Bureau, War of the Rebellion, Chart XL.

on account of hernia, a ratio of fifty per thousand.* The relative frequency of the different forms of hernia in those rejected was as follows:

Hernia, not specified	651
" umbilical	317
" ventro-inguinal	328
" right inguinal	8,598
" left "	5,420
" double "	1,166
" right femoral	277
" left "	110
" double "	34
Total	16,901

Symptoms.—There are certain signs common to all varieties of hernia, which may be enumerated as follows. 1. The presence of a swelling in certain defined localities, known as hernial regions; as in the region of the cord, the scrotum, the groin, or the umbilicus. 2. The swelling is usually painless, without unusual heat, and presents no discoloration. 3. The swelling is not fixed or permanent, but recedes and disappears entirely in the recumbent position,—or, at least, can be readily pressed back into the abdomen,—and reappears when the erect position is assumed. 4. In the act of coughing, a distinct impulse can be felt by the hand when placed over the tumor, and in the effort of straining or crying, a sudden enlargement will be observed in its size. 5. When the contents of the sac are entirely intestinal, the tumor will be elastic to the feel, resonant on percussion, and when returned will recede quickly in its entirety, and with a distinct gurgling sound or "*flop*." When the contents of the sac are exclusively omental, there will be an absence of resonance and of elasticity; there will be no sensible impulse communicated to the swelling either on straining or coughing; the tumor will have a doughy feel, and can only be restored, a small portion at a time, by taxis. When the intestines are distended by gaseous accumulations, no alteration of form occurs in the tumor. Omental hernia is most common on the left side. 6. When both intestine and omentum occupy the sac, the characteristic signs of each will be present, but so blended and modified that it will be difficult to determine with certainty by the touch the existence of both.

It is remarkable how little even large and unreduced herniæ interfere with the general health; and with many persons the only inducement to wear an instrument to retain the bowel in position is to get rid of the inconvenience of the bulky swelling.

Treatment.—The treatment of hernia is divided into the *palliative* and the *radical*. The palliative method consists in restoring the hernial contents to the cavity of the abdomen, and retaining them there by a properly-fitting truss. This should be done at the earliest possible moment. No patient is safe so long as the rupture remains outside of the body. Children form no exception to this rule, though some think it is better to delay the application of an instrument to such subjects until they are several months old, when the skin will be better able to endure pressure. If the precautions hereafter mentioned be used, there is no necessity for such delay.

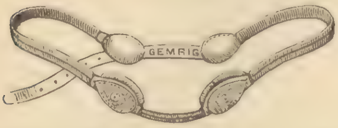
Many varieties of trusses are in use, some of which are very badly adapted to fulfill the end in view. The parts of a truss are a steel band to surround about two-thirds of the pelvis, a pad to command the hernial rings, a strap containing numerous holes in order to secure the apparatus in place, and sometimes an additional strap, used as a perineal band, to prevent the truss from slipping up over the hips.

The steel spring should be light and flexible, and covered either with leather or with hard rubber. The pad is formed of various substances, such as iron, wood, hard rubber, and sometimes stuffed leather. It should be plano-convex in form. It is connected with the spring by a flexible stem, or by screws passing through a slot in a piece of brass, by which its position can

* Medical Statistics of the Provost Marshal-General's Bureau, War of the Rebellion, p. 80.

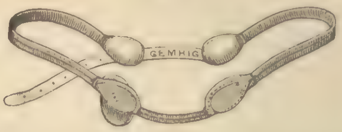
be changed according to the requirements of the case. Generally speaking, the hard pads are to be preferred both in point of comfort and efficiency. The Hood truss, as modified by Mr. Gemrig, of this city, and the hard rubber truss of Mr. Seeley, are among the most valuable forms of this instrument. The first, that of Mr. Gemrig's pattern (Figs. 298 and 299), is suited to either

FIG. 298.



Gemrig's modification of the Hood truss, suited to both single and double inguinal hernia.

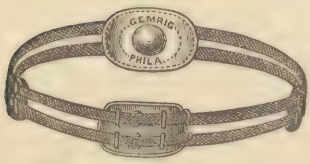
FIG. 299.



The pad turned down so as to answer for a femoral hernia.

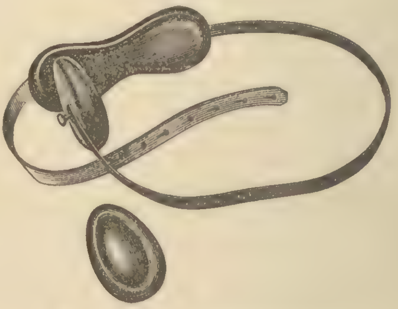
a single or double inguinal or to a femoral hernia. If properly fitted, it maintains its position with much certainty, and can be worn with great comfort by the patient. The same surgical cutler makes a very excellent truss for umbilical hernia, elastic bands being used instead of steel springs to keep the instrument in place. (Fig. 300.)

FIG. 300.



Truss for umbilical hernia.

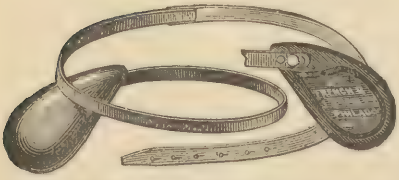
FIG. 301.



Hard rubber truss for inguinal hernia.

The hard rubber truss (Fig. 301) possesses in an eminent degree the properties of durability, lightness, and cleanliness. It does not absorb the per-

FIG. 302.



Hard rubber truss for inguinal hernia.

FIG. 303.

Hard rubber truss for both reducible and irreducible umbilical hernia.

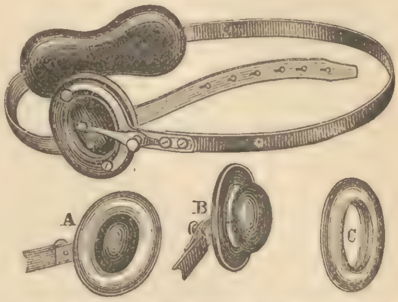
spiration from the body, and is not injured by moisture. Persons wearing this instrument can bathe without removing it from the body. Different forms of this truss are shown in Figs. 301, 302, and 303.

There are certain herniæ which require for their retention not only the compression of the entire canal, but, in addition, pressure concentrated at the external ring. These two indications can be very satisfactorily fulfilled by the truss represented in Fig. 304, in which the pad consists of two parts, an exterior or larger one, fashioned like a ring, and an interior or smaller one, which occupies the opening in the former. A spring, acting upon the

central pad, graduates the degree of pressure required. Other forms of trusses are in use (Figs. 305 and 306), and in many cases supply the necessary protection.

The Application of a Truss.—The presence of either a physician or a surgical cutler is usually necessary for the proper adjustment of a truss. Even with a large number of instruments at hand, it is seldom that one can be applied satisfactorily without some alteration being made. It should be adapted to the person of the patient so as to fit like a well-made garment. The strength of the truss should be sufficient to prevent a protrusion of the rupture, but not greater than will effect this end. I have seen the walls of the abdomen over the inguinal regions seriously atrophied and deep indentations made by the wearing of a very strong spring. Before applying the instrument, the person should assume the supine posture, with the shoulders elevated and the limbs drawn up, so as to relax the parts and to allow the contents of the sac to be pressed back into the abdomen. The hips should then be raised and the truss carried around the pelvis in the position which will be shown under the special forms of hernia. The strap being made fast, the patient may rise from the bed and assume the standing position. To be certain that the hernial passages are thoroughly secured, the patient may cough, bend forwards and backwards, stoop down with the limbs widely separated, and finally sit down with the limbs crossed. If these different tests be applied without the hernia escaping beneath the truss, the instrument may be accepted as a proper one. It is better not to wear a truss too long after its first application, as the skin is liable to excoriate, especially during warm weather; the instrument should be taken off in the course of five or six hours, and the removal must always be done in the supine position, never while on the feet. In order to harden the skin and render it tolerant of the pressure, the parts upon which the pads rest should be well bathed with alcohol containing a quantity of powdered alum, and then rubbed with the hand until they become red. Before rising, the truss must be again replaced. A little attention of this kind will, in the course of a few days, enable the person to wear the instrument without the least inconvenience: indeed, so callous does the integument become that many, after a short time, rarely remove the instrument night or day. If the hernia at any time slips out beneath the truss, the latter should be removed without a moment's delay. The person ought to lie down at once, and, by gentle pressure in the proper direction, restore the protrusion to its normal cavity, and, after being assured of its complete reduction, again apply the truss.

Fig. 304.

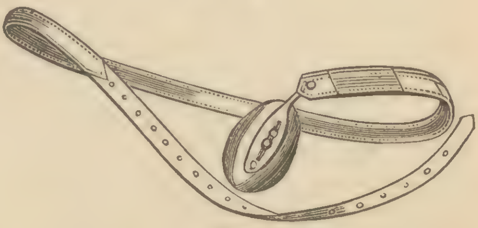


Hard rubber truss, designed to make both general and concentrated pressure. A, ring with centre pad; B, centre pad projected from ring; C, ring alone.

Fig. 305.

Single French truss.

Fig. 306.



Chase's truss.

Radical cure of hernia.—Many operations have been devised by surgeons at various times for the radical cure of hernia. Some of these have enjoyed a greater popularity than others, but not one can be said to command any large share of professional confidence. All of the plans which have been advocated have one object in view, that of obliterating the hernial passages by inflammatory adhesion in the walls of the sac. The most important will be presented, as follows:

1. *The truss.*—In infants, and in subjects under ten years of age, there can be little doubt that if a truss with a hard pad of wood, of ivory, or of rubber be worn continuously, day and night, the patient will be radically cured. In this class of persons the processes of development are in active operation, and if the sides of the sac be maintained in close apposition their consolidation will follow and the hernial passages be closed. Indeed, the tendency to recovery is so strong in children that the hernia sometimes undergoes a spontaneous cure. For this reason it is of the utmost importance that the truss be applied early, and be worn for two or three years continuously. After ten years of age, cures are much less likely to take place; and after adolescence they are not to be expected at all, under ordinary circumstances. I shall say nothing of the barbarous and repulsive methods of castration, the actual cautery, and excision of the hernial sac, which at one time, during the dark ages of the surgical art, were extensively practiced, but shall present some of the more important operations which have from time to time been devised for the radical cure of the disease. These may be considered under three divisions: 1, *invagination and circumclusion*; 2, *transplantation*; 3, *local irritants conjoined with compression.*

Invagination.—The principle of invagination has been put into operation in various ways, and is, in common with the other methods, for the most part applicable only to cases of femoral hernia.

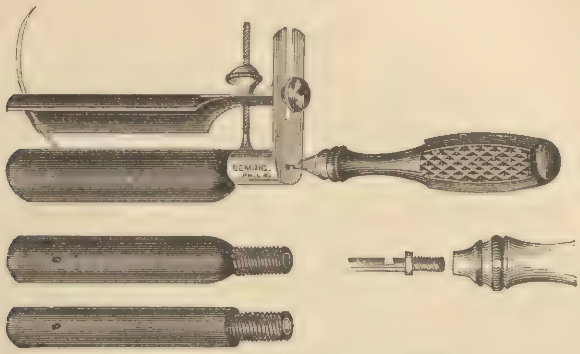
Gerdy's method.—This surgeon, on the tip of his finger, thrust the integument through the external abdominal ring into the canal, and up to the neck of the sac. Two double silk threads, half an inch apart, were next carried across the canal, from side to side, by means of a stout curved needle, the finger serving to protect the cord and the abdominal cavity behind, and by these threads the invaginated structures were brought into contact by tying their ends together over two cylinders of wood or a bougie, placed parallel with the canal, so as to form the quilled suture. After the removal of the finger, a camel's-hair brush, loaded with spirit of ammonia, was carried up into the invaginated pouch of skin, and applied freely to its surface, the object being to remove the cuticle and to secure adhesion of the contiguous parts. The threads were usually removed about the eighth day.

Signorini's method.—This plan differs from the preceding one in the following particulars: after invaginating the skin into the sac, a female catheter takes the place of the finger, and while the plug of tissues is in this way retained securely well up towards the internal ring, three long pins, a few lines apart, are passed across the canal, and the parts drawn tightly together by figure-of-eight turns with an equal number of threads.

Wutzer's method.—In 1838, Wutzer, of Bonn, planned a new method of occluding the inguinal canal by invagination. An instrument consisting of three parts, viz., a cylinder, a concave cover, and a long, curved, flexible needle, was employed for this purpose. Cylinders of different sizes, adapted to different ages, accompany the apparatus. The cylinder is from three-eighths to half an inch in diameter, about three inches long, smooth, and slightly flattened on one surface. It is rounded at one extremity, and at the other has two upright pieces of metal, one in the form of a round rod, and the other flat, with a slot. A canal runs through the centre of the cylinder, and opens upon its upper surface a short distance from the free or rounded end. This canal is designed for the passage of the curved needle. The cover is concave, and at one extremity is prolonged into a handle or process, having a hole for

the passage of the rod connected with the cylinder, and shaped so as to fit the slot of the latter; near its other end is an opening for the passage of the needle. A small screw upon the rod serves to approximate the cover and the cylinder. The cut below (Fig. 307) will make this description of the instrument intel-

Fig. 307.



Instrument for the cure of hernia, by Wutzer.

ligible. In performing the operation, the patient should be placed in the recumbent position, and the hernia, if out, returned into the abdomen. The surgeon now, on the end of the index finger, pushes up a portion of the scrotal integument through the lower ring into the canal. After this, the cylinder, without the cover, and with the needle withdrawn so that the point shall not appear, is conducted into the inguinal canal along the finger, and the latter withdrawn, after which, being assured, by the fixedness of the instrument, that it is properly placed, the operator pushes forward the needle, causing it to emerge through the anterior parietes of the canal and appear upon the surface of the skin. The concave piece is now fitted to the rod and slot of the cylinder, the needle conducted through the opening near its end, and, by means of the screw, the cover is run down, compressing with a moderate degree of firmness the structures interposed between the two parts of the instrument. The handle is now disengaged from the needle, and the point of the latter guarded with a small cork. The apparatus is allowed to remain seven or eight days, after which it must be removed; though the patient should not be allowed to rise from his bed for twelve or fourteen days later, and even then will require a truss for some months, to protect the parts until the consolidation of the cicatricial tissue is complete.

The author's operation.—This operation requires, first, an instrument in its appearance resembling a bivalve speculum, having two blades three inches in length, rounded at their extremities, and in one of which there are two longitudinal grooves. The handles are four inches long, are connected at an obtuse angle with the blades, and are controlled by a screw (Fig. 308).

Fig. 308.

Author's instrument for the cure of hernia.

Second, two needles, one long and slender (Fig. 309), the other short and strong, each curved at the extremity, at which there is an eye, and both mounted on wooden handles. The long needle should have a slight enlargement upon the metal three inches from its extremity, in order to determine

when its point has reached the end of the longitudinal groove in the blades of the speculum.

FIG. 309.

Author's needle.

The patient's bowels should be thoroughly opened on the day previous to the operation, after which he should be confined to the horizontal position. The hair being shaved from the pubis and the patient etherized, an incision is made over the scrotum through the skin, commencing at the external abdominal ring and terminating two inches below that point. The delicate integument is next carefully dissected away from the subjacent parts for some distance on either side. This accomplished, the exposed fascial and dartos structures are next lifted on the index finger and pushed through the external ring up to the summit of the canal. The speculum, closed, is now introduced along the finger, and when the operator is certain that it is properly placed, a fact which is determined by its immobility, the finger must be withdrawn. The blades of the instrument being next separated by running down the screw connected with the handles, the long needle, bearing a silver thread, is introduced into one of the longitudinal grooves and carried up to the end of the blade, when, its handle being depressed, the point is made to appear upon the surface of the body over the summit of the inguinal canal. The thread is now disengaged from the eye of the needle, when the latter is withdrawn, and, receiving the other end of the wire, is inserted into the other groove and carried, as in the first instance, to its extremity and forward through the superincumbent tissues, emerging upon the surface three-eighths of an inch from the first. The needle being removed and the two ends of the metallic thread drawn up, the invaginated structures will be securely maintained at the internal ring. In order to bring together the sides of the inguinal passage, to crowd together the parts which it contains, and to excite sufficient inflammation to glue them together, three transverse silk or wire sutures are next pushed across the canal between the separated blades of the speculum, by means of the shorter needle, and their ends tied together over a cylinder of lint placed upon the abdomen. The speculum being now removed and the wound in the integument of the scrotum closed, a compress of lint should be laid over the parts and the dressing retained in place by a spica bandage. To avoid all efforts at straining, the bowels should be kept closed for seven or eight days by opium, and the urine, if not easily passed on the side, must be removed by the catheter. The stitches should be taken away on the eighth day; but the patient must not be allowed to resume the erect position for ten days longer.

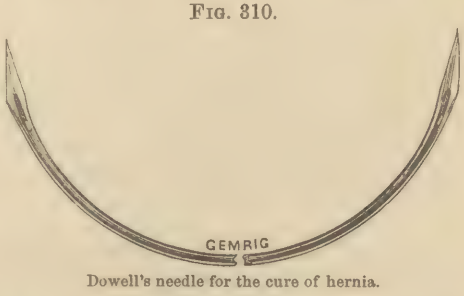
Wood's operation.—There are two operations known by this name. One is by an American surgeon,—Dr. T. Wood, of Cincinnati,—and the other by an English surgeon,—Prof. John Wood, of London. Both combine the principle of invagination with the approximation and union of the tendinous structures about the hernial passages. As the last has attracted considerable attention in England, it will be proper to describe it in this connection. The operation is a complex one, and somewhat difficult to understand.

The parts being shaved and the hernia reduced, an assistant makes pressure over the internal ring, to prevent any protrusion during the operation. The surgeon, beginning about two inches below the external ring, with a tenotome opens the skin of the scrotum for nearly an inch, and, insinuating the knife flatwise between the scrotal fascia and skin, separates the two for some distance on every side. The finger now lifts the raw surface which has been exposed and carries it into the inguinal canal, the parts being thoroughly relaxed by flexing the limbs, thus favoring this step of the

operation. With the point of the finger the margin of the conjoined tendon must be next recognized, when a strong, curved, blunt-pointed needle, mounted on a wooden handle, is guided along the invaginating finger beneath this aponeurosis and made to penetrate it from behind forwards. The skin is next drawn strongly upwards and inwards, and the needle pushed through sufficiently far to expose its eye, into which a silvered copper wire is hooked and brought out of the external wound as the needle is withdrawn. The wire is next disengaged from the needle and the latter conducted along the border of the finger and pushed through the aponeurosis of the external oblique muscle, close to its connection with Poupart's ligament, and opposite to the internal abdominal ring. The skin is now pressed inwards until the point of the needle is made to appear at the first puncture, when the upper extremity of the wire is hooked to the needle and conducted by the latter into the scrotal wound. The next stage of the operation consists in separating the cord from the hernial sac, which is accomplished by raising a fold of the latter at the upper angle of the scrotal opening and sliding the former back, very much after the manner of separating the vas deferens from the other constituents of the cord in the operation for varicocele. This effected, the needle is entered at the external wound, carried up along one side of the canal, passed across between the cord and the sac to the opposite side, and then brought out near the point where it entered, where it is again connected with one end of the wire, and, being withdrawn, conducts the copper thread along the same circuitous route and out of the opening in the scrotum. The two ends of the wire are now carefully straightened and drawn up until the loops appear at the skin, when they should be twisted together, a process which draws into apposition, in a spiral manner, the structures at the external abdominal ring. This ingenious subcutaneous loop not only secures the invagination of the scrotal tissues, but also approximates the boundaries of the inguinal canal, both transversely and antero-posteriorly. The patient is confined rigidly to bed, and on the eighth or ninth day the wire is untwisted, though it is not removed until about the fourteenth day.

Dowell's method.—Dr. Dowell, of Texas, has devised a plan, which consists in circumclusion of the boundaries of the inguinal canal. The preliminary measures of shaving the pubes and scrotum and opening the bowels, as in the operations already detailed, having been observed, the patient is placed in the recumbent position, with the shoulders elevated and the limbs flexed. The surgeon, after satisfying himself that the hernia has been entirely reduced, carries the index finger through the external ring and up into the inguinal canal, pushing before it the superimposed structures. He next takes a semicircular needle, sharp at either extremity, three inches long, with an eye near each point (Fig. 310), and armed with a strong silken thread. This needle is entered one inch and a half above the external ring, is carried across the inguinal canal, following the posterior edge of the tip of the finger, and is brought out through the skin on the opposite side, near to Poupart's ligament. This stitch passes through the integument, the aponeurosis of the external oblique, and the hernial sac near the posterior wall of the canal. Without entirely withdrawing the needle, as soon as the point becomes disengaged from the tendon it should be pushed back over the front of the finger, and made to emerge through the first puncture, or opening of entrance, near to Poupart's ligament. Both ends of the thread now lie together in the primary puncture, and the loop com-

Fig. 310.



Dowell's needle for the cure of hernia.

pletely encircles the inguinal canal. The next step is to remove the silk thread and replace it with a silver one. To effect this, it is only necessary to double the wire upon itself, and tie one end of the silk cord to the centre of the loop, when, by pulling upon the other extremity, the metallic thread is drawn in as the other is drawn out. This process is repeated two or three times, and each wire firmly drawn and twisted over a cylinder of lint placed upon the surface of the abdomen. Over these sutures is applied a little strip of gauze and collodion. The patient is to be rigidly confined to bed, the bowels kept quiet, and the diet restricted. After eight days the stitches are to be taken out, and in ten or twelve days more the patient may be allowed to rise and walk about.*

The operations just enumerated constitute the most important of those which have been planned on the principle of circumclusion. The practical question which arises from the consideration of the various plans for the radical cure of hernia is that of their true merit or claim to professional confidence. It is very difficult to determine the relative value of the different methods, as only in a few of the so-called successful cases have the patients been kept sufficiently long under observation to ascertain the permanence of the cure.

Of the sixty-two cases treated by Gerdy, four are known to have died, and as we have no means of discovering how many, if any, were radically cured, the fatality following the method is a sufficient reason for its condemnation. In regard to the operation of Wutzer, a countryman of this distinguished surgeon, Dr. Weber, who appears to have been cognizant of the result in fourteen persons operated on by Professor Wutzer, says that not a single case was cured; and such was my own experience in the few cases in which I employed this method. With reference to my own operation, the success obtained has not been sufficiently uniform to justify me in speaking of it in any other way than with distrust. Nor does the complex and ingenious method of Professor Wood, of London, command professional confidence. This surgeon has operated 155 times, with 113 cures, 40 failures, and 2 deaths. We should be able to form a more correct judgment as to the value of these statistics if the duration of the cure in the 113 cases could be ascertained.

Dr. Dowell, up to September 12, 1876, reports 96 operations for the cure of hernia by his method, with 80 cures and 16 failures.

This latter operation has been practiced on several patients in the University Hospital, by Dr. Hunter, and apparently with success; but the cases have not been followed sufficiently long to warrant any expression of opinion as to the permanency of the cure.

Transplantation.—The principle of blockading the hernial passages by the transplantation of tissue was first proposed by Dzondi. Dr. Jamieson, a surgeon of Baltimore, Maryland, treated successfully in this way a case of crural hernia. The patient was a female on whom the doctor had previously operated for strangulation. The bowel subsequently descending, at the request of the lady he undertook the radical cure, which consisted in laying open the parts, dissecting up a flap from the adjoining integument, turning the flap into the crural ring, and closing the soft parts over the fleshy mass by a number of interrupted sutures. This case I believe to be a solitary illustration, in this country, of the plan by transplantation.

Local Irritation conjoined with Compression.—The attempt to obstruct the inguinal canal by inflammatory adhesion of its contents to the surrounding walls has been made in different ways by exciting the necessary irritation in the sac. Belmas introduced pieces of goldbeater's skin and bits of gelatin; Professor Joseph Pancoast injected, by means of a fine trocar and canula, the tincture of iodine; Velpeau, with the same object in view, used scarification;

* Dowell on Hernia, Philadelphia, 1876, p. 67.

and still more recently Professor Armsby and Dr. Riggs have employed the seton. By all these surgeons the application of a truss was made a necessary part of the after-treatment.

Other plans for the radical cure of hernia have been devised, at various times, both in this country and abroad, but for the most part have long since passed into disuse.

Professor Gross advocates laying open the parts, and, after freshening the edges of the inguinal canal, uniting its sides by silver sutures.

After a careful review of the various operations proposed and practiced for the radical cure of hernia, not one can be said to be satisfactory; and it is a question admitting of grave doubt whether, in the present state of our knowledge on the subject, the surgeon is justifiable in resorting to any other treatment than that by a properly-adjusted truss.

Irreducible Hernia.

A hernia may be either *temporarily* or *permanently* irreducible. The first form is frequently designated as *incarcerated* hernia.

Causes.—Among the causes which render a hernia for a limited time irreducible are the following: an accumulation of gas, a collection of fæcal or other matter in the intestines, and an increase in the volume of the tumor by an unusual extent of protruded intestine or omentum.

Symptoms.—A person who is in the habit of wearing a truss neglects, in a moment of thoughtlessness, to put it on, or it may be that in consequence of some unusual effort the hernia slips out beneath the pad and is unduly compressed. In a short time, especially if the person has previously indulged in flatulent articles of food, he is seized with colicky pains, begins to eructate air, and suffers from nausea, which may end in vomiting. The hernial tumor becomes distended and often painful, and when percussed it may be found unusually resonant or flat, according as its contents are gaseous or solid.

Treatment.—Cases of this kind are frequently very injudiciously managed. Such a tumor is often attacked by a rude and protracted taxis, and is converted into one of acute strangulation by the induced congestion and even inflammation of the sac and its contents. The patient should be placed in bed, with the shoulders raised and the limbs drawn up, in order to relax the abdominal walls, and the scrotum should be elevated, with a view to relieve the dragging sensation so often felt. As the patient is often greatly alarmed in these cases of obstruction, the surgeon should quiet his fears and remove all unnecessary anxiety by the assurance that relief will be speedily obtained. When convenient, the patient may be placed in a hot bath, and a large enema of flaxseed-tea and turpentine or of salt water thrown into the bowel immediately after he comes out of the water. The warm bath tends to relax the parts about the region of the hernia, and the stimulating enema favors intestinal peristalsis, by which the obstruction causing the stricture may be moved from the protruded bowel. After the action of the injection, a very gentle use of taxis should be made, in the manner to be presently described, preliminary to which it is best to administer an anæsthetic, in order to insure complete muscular relaxation. Should these measures fail and the tenderness of the parts increase, ice may be applied to the tumor, and a cathartic administered. The sulphate of magnesia, given in drachm doses every hour, or a wineglassful of the citrate of magnesia, given every half-hour, is most likely to be retained by the stomach, and will in the course of six or eight hours produce, in some instances, free alvine discharges and the spontaneous recession of the hernia. In cases of this form of irreducible hernia unattended by a sick stomach, I much prefer castor oil to all other cathartics. It appears to excite a more energetic peristalsis than other members of its class, and in several instances of obstructed hernia I have by this article succeeded in effecting relief when other measures had failed. When the hernial protrusion is very sensitive and painful, and resists the usual meas-

ures for reduction, blood should be taken by leeches applied over the course of the cord, followed by the application of an ice-bag and the internal exhibition of opium with the extract of belladonna. One-third of a grain of the former with one-eighth of a grain of the latter may be given every two hours, lengthening the intervals of administration as soon as the narcotic effect of the prescription is produced. During this treatment the occasional use of enemata will prove serviceable. If under these agencies the sensibility, pain, and tension of the hernia abate, the taxis should be again cautiously attempted, or, what answers equally well, an elastic purse may be slipped over the tumor, the gentle but steady compression of which tends to dislodge the obstructing cause. When the obstacle to reduction appears to be a large accumulation of gas, a fine aspirating or hypodermic needle may be thrust into the tumor and the air drawn away. After exhausting the resources already detailed, and when the case culminates in strangulation, the knife becomes the last and only measure for relief.

Permanently irreducible hernia.—By such a hernia is meant one which cannot be restored into the cavity of the abdomen. The causes which produce such a result are numerous. Some of these affect the sac, others its contents, and others again the openings through which the hernia passes.

The changes which take place in the sac and render a hernia irreducible are the following. 1. The neck of the sac, when it is surrounded by the internal ring, has a plicated or puckered appearance. As long as these plaits do not adhere to one another, the neck is susceptible of expansion by the unfolding of these duplicatures. If, however, they become united by inflammatory changes, the orifice remains rigidly contracted and unyielding, and offers a permanent resistance to restoration. 2. The sac sometimes undergoes material alterations in form. It may become constricted at certain portions of its body, forming compartments with very narrow communications, in which its contents are permanently detained. The protruded structure in such cases is generally omentum. 3. The sac may become so enormously enlarged, and accommodate so considerable a portion of the intestine and omentum, that the consequent elongation of the mesentery and the contraction of the abdominal cavity will serve to defeat all attempts to restore the displaced viscera. 4. The contents of the sac may become adherent to each other or to the sac itself, in consequence of intercurrent inflammation attended with the transudation of plastic lymph, rendering their return into the abdomen impossible. 5. The transversalis fascia or its infundibuliform process may become extensively thickened by inflammatory deposits, and so adherent to the surrounding parts as to form an insuperable obstacle to the return of the hernia.

Irreducible ruptures, when neglected, are prone to increase in size, and when they become very voluminous the contents undergo material changes. In some instances these changes so completely obliterate the thin, supple, smooth, and moist condition of the omentum, converting it by interstitial deposits into a thick, stiff, irregular, and dry mass, that reduction is not only prevented but the membrane is even rendered unfit for a residence either in the scrotum or in the abdomen, and it has been known to cause an inflammation of the sac which has stealthily crept upwards and finally caused a general peritonitis.

Irreducible herniæ, especially when large, tend to develop symptoms of indigestion, in consequence of the hindrance offered to the circulation, to the peristalsis, and to the intestinal secretions. The consequence is, that patients suffering from such ruptures are often harassed by flatulent pains, eructations, and constipation. Many complain of a constant dragging sensation along the course of the cord, attended with uneasiness and weakness in the lumbar region. These symptoms arise from the stretching of the cord and from the irritation reflected along the ilio-lumbar nerve.

Treatment.—The chief indications in the management of an irreducible hernia are to prevent strangulation, to protect the parts against injury, and to

prevent a further increase in the size of the tumor. The patient should be exceedingly careful in regard to diet, avoiding especially all flatulent articles of food, such as onions, beans, boiled cabbage, sweet potatoes, or any article which is likely to cause an accumulation of wind in the intestines. The bowels must also be regulated by the use of oat-meal porridge, corn-meal, wheaten grits, stewed fruits, etc.; and should these not prove sufficient to secure a daily evacuation, a little rhubarb-root or a few senna-leaves taken at bedtime will have the desired effect. To prevent the increase of the rupture, and to shield it from injury, the use of a truss or a suspensory bag is all-important. When the hernia has not passed out of the inguinal canal, or when it belongs to the femoral or umbilical varieties, the pad of the truss should be made concave, so as accurately to receive into its depression the rupture and at the same time to make a slight degree of pressure upon its surface, in order to prevent a further protrusion. Should this cavity in the pad prove too large, it can be filled up somewhat with a layer of cotton. When the hernia has reached the scrotum, the proper apparatus will be a suspensory bandage, which should be drawn up firmly to impart the proper degree of support. Attempts are sometimes made to convert an irreducible into a reducible hernia. Where there is reason to believe that the obstacle to reduction is of recent origin, as the formation of an inflammatory adhesion, either from violence or from neglect to wear a truss, it will be proper to make an effort at restoration. With this end in view, the patient must be confined to bed, with the shoulders elevated and the limbs drawn up. Pressure over the tumor, to an extent not incompatible with the comfort of the person, should be made by a bag containing shot,—a kind of compress which adjusts itself neatly to the form of the surface upon which it is placed. The diet should be restricted, absorbents, like the iodide of potash and the bichloride of mercury, administered, and once in six or eight days an active purge given, both with a view to aid in the absorption of the incarcerating bands of lymph which detain the contents of the sac in their unnatural location and to detach and separate the same by exciting active peristaltic movements in the protruded bowel. If such a course be maintained for three or four weeks, the surgeon will occasionally have the satisfaction of finding the hernia restored to the abdomen. Except, however, where the irreducibility depends upon a cause like the one above mentioned, the probabilities of restoration, in the form of hernia under consideration, are so slight that it will be useless to subject the patient to any such course of treatment.

Strangulated Hernia.

Strangulated hernia is that condition in which the contents of the sac are so constricted or girt about that there follow pain, obstruction, vomiting, irreducibility, and absence of expansive impulse. Some idea of the relative frequency of strangulation in the different varieties of hernia may be formed from a collection made by Hancock* of 529 cases, of which number 250 were femoral, 250 inguinal, 16 umbilical, 8 congenital, and 5 ventral.

Strangulation is in most instances a sudden event. A person in a moment of forgetfulness, or it may be of carelessness, leaves off his or her truss. An attack of coughing, straining at stool, or a long walk forces an additional coil of intestine or fold of omentum into the sac and causes at once the characteristic symptoms of serious constriction. The same result may arise from a disturbed peristalsis, from distention of the intestine by gas, or from its impaction by fæcal and other accumulations. In a case of strangulated hernia in the person of a negro operated on by Dr. Mastin, of Mobile, the intestine was filled with a large number of the small bones of a pig's feet which had been swallowed along with the flesh. There may be also such an entanglement of, or inflammatory change in, the contents of the sac as to cause strangulation. From whatever cause the latter may arise, the danger is momentarily increased by the impediment offered to the circulation in the walls of the

* Hancock on Strangulated Hernia.

intestine or in the omentum, in consequence of which they become swollen, congested, and of a dark or purple hue.

In this state, the contents of the sac are exposed to death in one of two ways,—either from being entirely deprived of blood or from an inflammation which will terminate in mortification. In the first condition the loss of vitality may follow in a few hours, and answers to what is termed acute strangulation; in the second the progress of the disease is slower, and may extend over many days, constituting chronic strangulation. A recent hernia is less liable to this accident than an old rupture. In the former, however, when stricture does take place, the danger to the intestine is very great.

Large herniæ are less liable to become strangulated than small ones, and when this condition does occur the symptoms are not so urgent as in the latter. The effect of a stricture upon two or three loops of intestine is less obstructive to the circulation than when it includes only a single coil of the bowel. In the first case the surface embraced is irregular, allowing some channels to remain open for the passage of blood, whereas the reverse is true in the second. The addition of the omentum to the contents of the sac will, for the same reason, diminish the risk of rapid mortification. Mr. Bryant has shown, in a paper based on the statistics of Guy's Hospital, that the average duration of inguinal hernia before becoming strangulated is twenty years, and that when a recent rupture of this variety becomes strictured it is usually of the congenital kind. The same paper makes the average duration before strangulation, in femoral hernia, eleven years, and in umbilical rupture constriction is much less frequent than in either of the other forms.

Seat of stricture.—The seat of stricture may exist at the rings, and at the neck of the sac, or the constriction may be caused by adhesions or entanglements between the contents of the latter. When situated at one of the rings, the strangulation is not caused by the contraction of the ring upon the neck of the sac,—since, consisting of fascial or tendinous material, it does not possess the property of contractility,—but by the great disproportion between the bulk of the rupture and the opening through which it passes; in other words, this ring does not contract upon the hernia, but the hernia presses against the ring. In the inguinal variety the internal ring and the neck of the sac usually form together the seat of constriction. The neck of the sac, being plicated or thrown into duplicatures by passing through the ring (Fig. 311), cannot become unfolded unless the latter will yield; or it may happen that the contiguous surfaces of the plications of the sac have become adherent through inflammatory lymph, and, in this way being rendered incapable of expansion, cause stricture of the hernial contents.

Fig. 311.

Plicated arrangement of the neck of the sac.

In femoral hernia, the rupture is subjected to the resistance of the strong membranous aponeuroses, Hey's and Gimbernat's ligaments, in addition to that of the neck of the sac.

Effects of strangulation on the contents of the sac.—These effects differ according to the tightness of the stricture. A few hours, in some instances, may suffice to destroy the vitality of the extruded parts, while in others the strangulation may continue for five or six days without hopelessly impairing the integrity of the imprisoned structures. Whether the case be acute or chronic in its nature, the first effect is to obstruct the circulation, causing *congestion* in the contents of the sac, in consequence of which the intestine becomes of a claret color, gradually deepening into a livid or a purple hue. The effect of this congestion is to produce points of ecchymosis and also serous transudation into the structure of the bowel. The omentum, when it forms a constituent of the strictured hernia, will exhibit the same condition of engorgement, though not to the same degree. Its veins will be distended, but its color will not be so dark as that of the intestine under similar circumstances.

Not only does the transudation of serum interpenetrate the coats of the intestine, but a considerable amount is poured out into the sac. Should the strangulation not be relieved, the parts pass into a state of intense inflammation, lymph is effused into the structure of the bowel, destroying its pliability and softness, and in some degree also its smooth, moist, and glistening appearance, and rendering its surface rough. Sometimes the hernial contents will be found adherent to one another, and to the inside of the sac. If the progress of the inflammation continue unchecked, mortification sets in, sometimes including the entire loop of intestine, at other times affecting only spots at different parts of its surface. This change is indicated by the appearance of ash-colored and also black sloughs which give way readily under moderate pressure, by the presence of bloody serum in the sac, and often by an offensive odor, the result of commencing decomposition. The omentum, when it participates in the constriction, may perish in part or in mass, preliminary to which it often changes from a red to a green hue, and finally to a deep-black color. The surgeon should not too hastily conclude that an intestine is hopelessly disorganized because its surface is ecchymosed, its color very dark, and the sac filled with a blood-stained serum. All these changes may take place and still the bowel may recover if relieved of the constriction. During the process of inflammation and mortification the parts of the neck of the sac become closely adherent to the surrounding tissues, thus forming a barrier against fæcal and other extravasation into the peritoneal cavity during the separation of the extruded parts. It is remarkable how long the process of destruction may continue without the inflammation extending to the serous lining of the abdomen. Many persons perish without any peritonitis whatever, though generally a low form of the disease is developed, which, like that from ordinary causes, is followed by the agglutination of the coils of intestine to one another, and the presence of a dirty serum and masses of unhealthy lymph within the cavity of the abdomen. The mortification of the contents of the sac, and of the sac itself, is the signal for inflammatory changes in the superincumbent structures; the skin becomes red, tender, and swollen, and at last assumes a green color; the parts crackle beneath the fingers from the elimination of gases, become infiltrated with a bloody, fetid pus, and rapidly pass into ulceration, in consequence of which an artificial anus is established.

Symptoms.—The signs of strangulation may come on gradually, or they may appear suddenly in a few minutes. The tumor becomes distended, resonant, tense, tender, and painful to the touch; the hernia, if reducible before, cannot now be returned; pain is experienced in the abdomen, generally referred to the region of the umbilicus; a sense of constriction around the body is often complained of; the characteristic impulse in the rupture is lost, and the patient frequently lies with the limbs drawn up, in order to relax the muscular parietes of the belly. When the tumor consists chiefly or exclusively of omentum, the bulk of the swelling is not materially changed by the strangulation, and instead of the enlargement being tense, elastic, and resonant it is soft and yielding, and gives a flat sound on percussion.

In a short time symptoms of a more general nature arise. A consciousness on the part of the patient of what has occurred is followed by mental agitation, alarm, and great restlessness. Evacuations may be secured by enemata, but they come from that part of the intestine below the stricture, the latter forming an impassable barrier to the contents of the bowel above and causing constipation. The obstruction is soon followed by nausea and vomiting. The matters first thrown up are the articles of food which have been recently taken into the stomach, followed by ropy mucus and bile, and finally by the feculent contents of the intestine,—the so-called stercoraceous vomiting. If the case be allowed to advance without interference, the changes consequent on inflammation of the protruded structures give rise to symptoms of a still more alarming condition. The abdomen becomes tympanitic and tender; the patient lies with the shoulders elevated

and the limbs drawn up; the circulation is quickened, the pulse being feeble and frequent; the tongue becomes dry and brown, the countenance pinched and anxious; the eyes lose their lustre; and when, at last, mortification begins, the pain suddenly leaves the tumor, a cold sweat breaks out over the surface of the body, followed by hiccough, an intermittent pulse, quiet, muttering delirium, and extreme prostration, the scene being soon closed by death. The event usually takes place, unless prevented by the formation of an artificial anus, in five or six days. Death, however, is not always the result of mortification. Many persons die from shock, and many from peritonitis, without the vitality of the imprisoned contents of the sac being seriously impaired.

Diagnosis.—Generally there is little difficulty in recognizing the existence of a strangulated hernia. The presence of a tumor in one of the usual hernial regions, possessing a certain amount of tenderness, without impulse, and the obstinate retching, vomiting, and constipation which usually accompany it, form a collection of appearances which rarely lead the practitioner astray. Yet cases will occur in which the diagnosis cannot be established without the most critical investigation. Thus, in concealed inguinal hernia a portion of the intestine may be strangulated at the internal ring, so small as to render it impossible for the surgeon to discover its existence, either by sight or by touch. I have witnessed a number of deaths from this form of hernia, which had been treated as cases of colic. In all instances of abdominal pain, the practitioner should examine the rings in view of a probable strangulation. In most cases of concealed strangulation there has been a pre-existing history of hernia, for which the patient has worn a truss. If with such a history there exist the constitutional signs of a strictured rupture, even though no tumor can be discovered, this fact should lead the surgeon to expect its existence, and will warrant an exploratory operation to verify or disprove the conclusion.

A hernia may become either permanently or temporarily irreducible, and give rise to symptoms simulating strangulation. Thus, an old rupture sometimes becomes swollen from an accumulation of gas, and in this state is followed by constipation and vomiting. In such a case, however, the characteristic impulse is present, there is no pain in the swelling or in the region of the umbilicus, the vomiting is not stercoraceous, and the strength of the patient is little affected,—symptoms which do not, as a rule, answer to strangulation. A hernia which is irreducible is exposed to attacks of inflammation, in which condition the resemblance to strangulation is very close, in consequence of the extremely sensitive state of the tumor, and its feeble impulse, together with the existence of constipation, flatulence, and vomiting. I have been frequently called to operate in such cases under the supposition that the bowel was strictured. There are, however, several notable differences between this condition and that of strangulation. The sensibility and pain of the swelling in the inflamed hernia are, as a rule, much greater than in the other, though the abdominal tenderness is less; the impulse, though diminished in force, is not entirely obliterated; the constipation, though obstinate, is not complete; the vomiting is neither persistent nor of the fæcal character; nor is there the same degree of prostration, restlessness, and anxiety as in strangulated hernia.

When a person having a double hernia is attacked with symptoms of strangulation, the surgeon may be greatly perplexed to determine which is the subject of constriction. A case was related to me by a medical friend in which three herniæ existed in the same person, two being inguinal and one femoral, all irreducible. The woman was attacked with the usual signs of strangulation. It was impossible, by any external examination of the tumors, to identify the one involved. Herniotomy was performed on one without success, and on the second with a similar result, the third proving to be the one affected. No other resort is left to the surgeon under such circumstances than to operate, selecting the hernia which furnishes, on a careful examina-

tion, the strongest evidence of being the subject of stricture. If the patient be a female, and there be present an inguinal and a femoral rupture offering alike negative signs of strangulation, the femoral should be selected for operation, as being the one most likely to cause the trouble.

Treatment.—How to manage a strangulated hernia is a subject of the deepest interest to both patient and practitioner. It is not exceeding the truth to say that many lives are sacrificed annually by improper treatment. The great indication is to overcome the stricture, and, when the procedure is not contra-indicated by structural change, to restore the hernial contents into the abdominal cavity. The two means for accomplishing this end are *taxis* and *herniotomy*. The longer a rupture remains strangled, the greater will be the danger and the greater the difficulty in reduction. These are cogent reasons for an immediate resort to such measures as promise relief. The risk of mortification or of inflammation and its consequences is greater when the tumor is small than when it is large, for reasons already stated.

When called to a case of strangulated hernia, it is the duty of the physician to proceed directly to its reduction. The patient should be placed in a horizontal position, and ether or chloroform administered, so as to secure the most thorough muscular relaxation; before which it should be understood by the individual that, in the event of a failure to return the rupture, the operation shall proceed at once, while he is still under the influence of the anæsthetic. The use of ether or chloroform takes the place of the formidable preliminaries to which persons were subjected under the old system of reduction, namely, venesection, tobacco clysters, hot baths, etc. The next step is such a disposition of the body and of the limbs as will secure the most thorough relaxation of all the tendinous, muscular, and other structures concerned. This position is very much the same for all varieties of hernia, namely, the head and shoulders elevated, with the lower extremities flexed and drawn up towards the abdomen. If the hernia be femoral, in addition to flexion, the knee of the affected side should be turned inwards towards its fellow-member.

Taxis.—This term is derived from the Greek word *τάσσω*, signifying to put in order. In the hands of unskillful men the taxis serves to put things very much out of order, and it should be undertaken only under a clear apprehension of the regional anatomy of the hernia and the *rationale* of the force to be employed. Some proceed, it would seem, under the impression that the work is to be done by force; others act as though the whole manipulation consisted in pushing. Now, it should be clearly understood that neither the one nor the other is proper; that the parts must be handled with great gentleness, and not rudely, otherwise inflammation may be provoked, or even rupture of the sac or of the intestine may follow. When the force is applied by pushing the mass upwards, it will merely crowd the contents of the sac against and around the seat of stricture, or force them into some side-pouch. The two dominant thoughts in the use of the taxis are to steady the neck of the sac and to empty the intestine of its contents, for by so doing the disproportion in size between the bowel and the rings is lessened. As soon, therefore, as the patient is rendered insensible and the parts are properly relaxed, the surgeon, if the hernia be an inguinal one, places the thumb on one side and the fingers on the opposite side of the external ring, so as to prevent the sac from bulging over the pillars of the latter; with the other hand he grasps the body of the tumor, and, first drawing it downwards and outwards, in the line of the canal, so as to straighten the cavity of the bowel, he begins to compress the hernia with a moderate degree of firmness, graduating the force in such manner that, with the exception of the fundus, where it should be greatest, the pressure shall be evenly distributed over the tumor. This compression must be maintained continuously for eight or ten minutes, when perhaps a peculiar sensation will be felt and heard (gurgling), caused by the air passing out of the rupture. This is the sure precursor of reduction, and in a few moments

more the sudden slip of the entire contents back into the abdomen will be noticed. When the omentum alone is the occupant of the sac, the restoration is effected slowly, one fold after another of the membrane receding until all is replaced.

In applying taxis to femoral hernia, should the tumor have turned upwards over Poupart's ligament, it must first be dragged down into the groin, after which the thumb and fingers of one hand should be placed on opposite sides of the saphenous opening, while with the other the rupture is compressed and simultaneously pushed backwards and slightly upwards, in order to direct it into the saphenous opening and through the femoral ring into the body. There is a limit to the use of the taxis. If the reduction is not accomplished in ten minutes, our efforts should cease, and resort should be had at once to the knife. A large or an old hernia will tolerate a longer manipulation than a small or a recent one. In any event, taxis should not be persisted in for more than ten minutes. Not unfrequently the hernia has been subjected to prolonged manipulation before the surgeon is called, and, if there is reason to believe that the taxis has been used properly, it will be better to confine further efforts at replacement within the limits of five or six minutes. When, from handling, the hernia has become exceedingly sensitive or painful, and when there is reason to believe that mortification has begun in the contents of the sac, taxis is not allowable. Mr. Birkett thinks that the presence of hiccough contra-indicates the employment of taxis. This is the case when, associated with the sudden subsidence of pain, there are present a feeble, frequent pulse, and cold sweats, with extreme prostration, as these are the signals of commencing mortification; but hiccough is sometimes present when there is no evidence whatever that the vitality of the hernial contents is destroyed, and under such circumstances manual attempts at reduction should not be withheld.

Surgeons sometimes place the patient in unusual postures as adjuvants to the taxis; such, for example, as laying the person on an inclined plane, with the head and the shoulders low, and the limbs bent over on the abdomen; or suspending the individual by the heels; or simply raising the pelvis upon a pillow, the thorax and lower limbs being at the same time flexed upon the body. Another device consists in grasping the relaxed parietes of the abdomen and pulling them as far forward as possible. A folded sheet has been passed around the lower part of the body and the viscera forcibly drawn upwards. A sudden douche of cold water upon the epigastrium, when the walls of the abdomen were relaxed, causing a forcible inspiration, has succeeded in replacing a hernia when other methods had failed. In one instance I knew a rupture to be restored by the patient's horse taking fright and upsetting his wagon, after prolonged taxis had been unsuccessfully applied.

Persons from long practice often acquire a remarkable tact in reducing their own herniæ; and in such cases the surgeon should never discourage them from making the attempt. I recall an instance of a large rupture, in which the patient, after a fruitless manipulation, replaced the bowel by pressing the tumor between his thighs. Spontaneous recession of a protrusion, after repeated taxis, has often occurred. In two cases within my own knowledge in which the patients were given over to the knife, the usual means of reduction having been exhausted, the hernia disappeared while the surgeons were preparing for the operation. In ruptures where the bowel has been greatly distended with gas, restoration has been accomplished by puncturing the intestine with a very fine trocar and canula or with an aspirator, thus liberating the imprisoned air. I have used for a similar object the needle of the hypodermic syringe.

Inguinal hernia is much more frequently restored by taxis than is femoral; and it should not be forgotten that, as a rule, the last form of hernia is much less tolerant of manipulation than the first.

The reduction of a hernia does not always remove the strangulation; and when this is the case there is ground for the gravest apprehension. The

circumstances which may continue the symptoms are the following: the hernial contents instead of receding singly and independently of the sac may be returned along with the latter; this is termed reduction *en masse* or *en bloc*; or the strangulation may be due to bands, or to entanglement existing between the omentum and the bowel, in any of which cases the restoration does not remove the cause of stricture. Again, the constriction to which the bowels have been subjected by the stricture may be so great that the peristalsis of the tube remains paralyzed; and, lastly, the rupture may, in consequence of the sac giving way, be thrust into some side-pocket, or between the peritoneum and its underlying connective tissue, as shown by Mr. Birkett, so as to be out of sight and leave the impression that it has been properly reduced.

Other cases are met with, generally in connection with congenital hernia, in which diverticula are formed from the inguinal sac, extending downwards and backwards beneath the iliac fascia into the iliac fossa, or inwards into the loose tissue in front of the bladder, between the pubes and the peritoneum, or upwards between the integuments and the external oblique muscle. These are examples of what are termed *interstitial* or *intraparietal* herniæ.

The recognition of any of the above conditions which serve to continue the symptoms of strangulation must necessarily be a difficult task; indeed, their existence will, in most instances, be purely a matter of conjecture. When a hernia is reduced without sensible sound or gurgling, and the canal appears to be unusually collapsed, or when the rings are very free and open and no membranous structure answering to the sac can be felt in the hernial track, a reduction in mass may be suspected. It has been said that this accident occurs only in inguinal hernia; yet I twice saw it take place in cases of femoral hernia. When reduction is noiselessly effected and the sac notwithstanding remains in the inguinal passage, the signs of constriction still continuing, the case is possibly one of entero-epiplocele, in which either an adherent band exists or some entanglement remains between the bowel and the omentum.

The condition which has been named peristaltic paralysis of the intestine furnishes no characteristic signs. If in restoring a hernia the usual gurgling sound has been present, and the sac can be detected lying in the canal, and yet symptoms of strangulation persist, the existence of such a state is not improbable.

When the hernia has been forced into some recess between the layers of the abdominal parietes, its existence will be a matter of speculation; though if the tumor has lessened gradually under pressure, and finally disappeared without gurgling or jerk, and the vomiting and distress still continue, such a state may be suspected.

The proper course to be pursued in the complications described is, at first, one of expectancy. Stercoraceous vomiting, pain, and tympany may continue for a short time after the reduction of a hernia, and yet afterwards gradually subside and the patient recover. This perpetuation of the symptoms of stricture may be due to local peritonitis or to the muscular paralysis of the bowel, which, after the disappearance of the serous inflammation or the gradual recovery of the suspended function of peristalsis in the bowel, will pass away. When, however, the strangulation persists over eight or ten hours, an exploratory operation will be proper. The canal should be laid open, and if it is found vacated by the sac the evidence of a reduction in mass is complete. The sac may have receded from the inguinal canal and yet still be engaged in the internal ring. In either event, the reappearance of the hernia should be solicited by causing the patient to cough, and at the same time drawing down the sac, if it is found at the upper ring. If the surgeon, by these measures, is successful in effecting the redescent of the rupture, the sac should be opened and its contents liberated, as in ordinary cases of strangulation. If after this the symptoms continue, there is reason to suspect the existence of bands or entanglement; but the

duty of the practitioner, so far as operation is concerned, ceases when the interior of the sac is explored. If the explanation is not found there, further search, by opening the cavity of the abdomen, is scarcely a justifiable procedure. If the sac is found ruptured, an accident which renders probable the existence of an intra-parietal displacement of the hernia, forcible coughing should be enjoined, in the hope that by such effort the patient may succeed in dislodging the viscus from its unnatural position and enable the surgeon to relieve the constriction and restore the rupture.

Rupture of the intestine is an accident which may follow the too forcible manipulation of a hernia, especially when the coats of the bowel have become softened through inflammatory or other changes. The occurrence would be indicated by the sudden collapse of the distended tumor and the rapid development of pain and of tympany, phenomena which follow fæcal extravasation into the peritoneum. Such cases will prove rapidly fatal.

After reduction has been successfully effected in cases of strangulated hernia, the vomiting, pain, abdominal distention, anxiety, and exhaustion soon disappear, provided the contents, when replaced, are not hopelessly damaged or peritonitis does not supervene. The patient, however, should be confined to bed for three or four days, the diet being restricted, and on the second day the bowels may be opened either by an enema or by a gentle aperient. Before he leaves the recumbent position, a truss should be adjusted to prevent a recurrence of the protrusion.

HERNIOTOMY.—The operation of herniotomy consists in dividing the superincumbent coverings of the rupture, relieving the stricture, and restoring the contents of the sac into the abdomen, unless the latter proceeding is contra-indicated by conditions hereafter to be described.

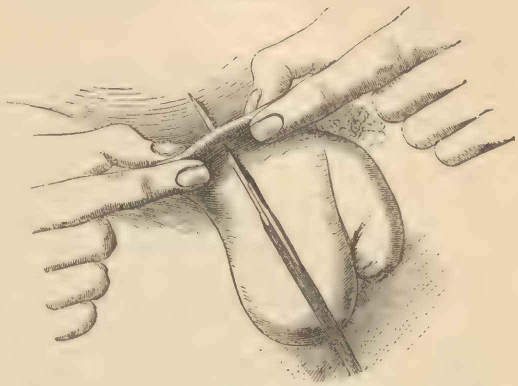
The time to operate is immediately after the taxis has failed and before the patient comes from under the influence of the anæsthetic. The most convenient position for the surgeon is to place the patient either across the bed, the hips resting upon its edge, and the feet supported upon a low stool, or, what answers equally well, to bring the patient to the side of the bed. The hair over the pubes and scrotum on the side of the hernia should be cleanly shaven, and if there is reason to believe that any considerable accumulation of urine exists in the bladder, it must be drawn off with the catheter. A single assistant, in charge of the anæsthetic, is all the aid required; though a second one, who shall attend to the sponging and, if necessary, to the ligatures, will facilitate somewhat the rapidity of the operation. These preliminaries having been arranged, a linear incision should be made over the tumor, extending from its upper to almost its lower extremity. This incision may be linear and direct, which I prefer (Fig. 312), or it may be made by raising a fold of the integument, transfixing the same with a sharp-pointed bistoury, and cutting from within outwards. (Fig. 313.) The layers are to be lifted on a grooved director and divided until the sac is reached. It should not be forgotten that the coverings of the hernia are sometimes extremely thin, and should the first incision be made with a heavy hand the knife may pass through into the bowel. I once saw this accident occur in the hands of a surgeon; and the

FIG. 312.

Direct linear incision over the hernial tumor.

impression which was made upon my mind has never passed away. It is proper to observe here that it is not necessary to separate layer after layer, in the order pursued by the anatomist in a class-room demonstration, but simply to divide cautiously all the structures overlying the sac. Any vessels which bleed freely should be tied, in order that nothing may interfere with the succeeding steps of the operation. Considerable embarrassment is often experienced in recognizing the sac. It usually appears as a round or an oblong tense bag, having a bluish color, and with some fine, straggling vessels scattered over its surface. Though generally a thin membrane, it is occasionally thick and almost of a leathery consistence and feel. To remove all doubts, it may be grasped between the thumb and fingers, and if its opposite surfaces can be rubbed or slid upon each other its identity will be established; or if there remain still some obscurity or uncertainty, let a puncture with a fine needle be made into the part, when, if it be the sac, the escape of a few drops of serum will declare its true nature.

FIG. 313.



First incision, by transfixing a fold of integument over the hernial tumor.

Opening the sac.—The sac having been exposed, the most important question in connection with the entire subject of hernia arises,—Shall it be opened or not? If the reduction can be effected without opening the sac, a great work has been achieved; indeed, the operation, in that event, is very simple and almost entirely free from danger. By this method the peritoneum is not wounded, the intestine and omentum escape being handled, and there is no risk of blood entering the cavity of the abdomen. Petit, in 1718, over one hundred and fifty years ago, earnestly inculcated this plan of performing herniotomy. More than thirty years before, Ravaton had introduced it to the notice of English surgeons. There is reason to believe, however, that Franco, who first operated for strangulated hernia as early as the sixteenth century, was in the habit, when possible, of not laying open the sac, and the same practice was inculcated by Ambroise Paré and Ledran, and in more recent times by Bonnet, Roser, Bransby Cooper, Diday, Dunzel, and others. Mr. Ashton Key, in 1833, published an able paper upon the subject, which had the effect of popularizing the operation of reduction without division of the sac, not only in Great Britain but also in other countries. Of 125 cases of herniotomy furnished by Mr. Gay,* in which the old plan was adhered to, 52 died, whilst in 73 cases in which the sac was not opened the mortality was 13. Mr. Luke operated on 82 cases. In 57 the hernia was reduced without opening the sac, and of this number 7 died. Of the 25 in which the sac was divided 8 died.† In a summary of 59 cases of femoral hernia operated on in Guy's Hospital during a period of eight years, in which the sac was divided, the mortality was 50 per cent., whereas in 45 cases in which it was not disturbed the death-rate was 30 per cent. Of 35 inguinal herniæ, in the same institution, requiring operation, and where the sac was opened, 60 per cent. died; and in 9 instances in which it was not so treated, 2, or 22 per cent., died,—a difference of 40 per cent. in favor of Petit's method.‡ In a collection by Hancock § of 548 cases of hernia requiring

* Gay on Femoral Hernia, 1849.
† Medico-Chirurgical Transactions, vol. xxxi., 1848.
‡ Bryant's Surgery, p. 318.
§ Hancock on the Operation for Strangulated Hernia, 1850, p. 53.

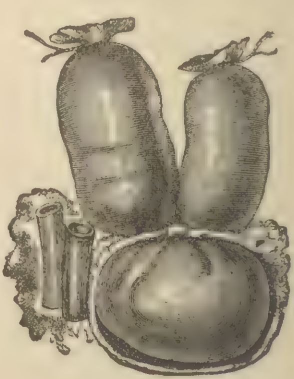
operation, the sac was opened in 474. Of this number 307 recovered and 167 died; and of the 74 in which it was not opened 52 proved successful. The fatality following the ordinary operation is also well shown in the 545 cases collected from various sources by Turner, in which the sac was divided, 260 of whom died. There is reason to believe that in femoral hernia the necessity for observing the Petit method is less urgent than in the inguinal varieties. Dr. Dutrelepont* reports 12 cases of strangulated hernia operated on without opening the sac, with a single death. In my own experience, the Petit method has been so successful that I never think of dividing the sac except in cases where its contents cannot be restored, or where, in consequence of the long time that the hernia has been strangulated, there are strong reasons for believing that the parts are not in a condition to be returned into the abdomen. Those who oppose the practice do so on the ground that there must always be some uncertainty in the mind of the surgeon as to the state of the contents when the sac remains unopened. It is possible that an error may be committed on this point; but I apprehend that for every life lost from this cause fifty are sacrificed by unnecessarily dividing the sac to inspect the intestine and omentum. No surgeon is deterred from attempting the reduction of a strangulated hernia by taxis at any time short of the appearance of mortification, and yet there must be a like ignorance in regard to the state of the parts which he returns into the abdomen.

As soon as the sac is exposed, it should be carefully divested of all bands of connective tissue about its neck, and the index finger carried up in order to discover the seat of constriction. (Fig. 314.) In femoral hernia this is found at Hey's ligament, the sharp edge of which stretches across the sac, or it may be at the neck of the latter. In inguinal hernia the stricture is generally at the neck of the sac (Fig. 315), and next in frequency at the internal

Fig. 314.

Finger seeking for the stricture.

Fig. 315.



Stricture at neck of sac.

ring, where there will be found bands of dense connective tissue, which resist the reduction by preventing the dilatation of this portion of the sac, and which should be carefully cleared away. The next step consists in dividing the stricture, wherever found. This is a work often of great delicacy. There are three objects to be kept in view in executing this part of the operation: first, to make no further division than is just necessary to relieve the hernia from constriction and admit of the easy reduction of its contents; second,

* Langenbeck, Archiv für Klinische Chirurgie, Berlin, 1868, Bd. ix. p. 471.

not to injure the intestine or omentum; and, third, to avoid wounding important blood-vessels. The simplest plan is to carry the index finger to the seat of stricture, with its palmar surface looking upwards, its dorsal surface

FIG. 316.

Cooper's hernia bistoury.

at the same time serving to keep the sac out of the way. By a little patience and address, the nail may be insinuated beneath the edge of the constricting band, when the hernia bistoury of Cooper (Fig. 316) can be conducted flatwise along the finger to the point of resistance, beneath which the blunt point of the instrument should be pressed, and then, being turned with its edge against the stricture, a little pressure by the finger beneath will answer to nick the part, after which, the knife being withdrawn, the finger can usually effect a sufficient dilatation to allow of the reduction. If the division is not sufficient, the operation can be repeated until the object is attained. A too free use of the knife is to be deprecated, as it tends to weaken the parts and increase the tendency to future hernial protrusions. A number of ingenious contrivances have been devised in order to divide the stricture without exposing the intestine to injury. For this purpose the notched director of Dr. Levis (Fig. 317) answers a very good end when Hey's ligament is the seat of strangulation.

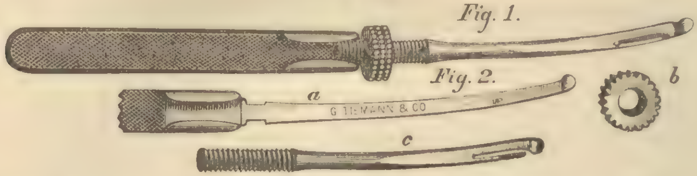
FIG. 317.

Levis's notched director, on which to divide the stricture in hernia.

When it is found that, after thinning the neck of the sac and removing all sources of exterior constriction, it is impossible to return the hernia, the sac must be opened. This is best done by pinching up, with a pair of forceps, a little duplicature on its anterior surface and nicking it with the knife the edge being placed horizontally, after which a director should be introduced, and by means of a pair of scissors the opening can be enlarged upwards towards its neck. Some caution is necessary in doing this, that the intestine be not wounded. The fluid contained in the sac defends its contents from injury by occupying the space between the two, just as in ascites the serum interposed between the intestines and the abdominal parietes allows the cavity to be tapped without damage to the viscera. In some instances there may be little if any fluid in the sac, and then increased care must be observed. It is not necessary to lay open the sac in its whole extent; only the upper half will require division, as the less extensive the wound in this structure the better, for it is this damage which inaugurates the peritonitis likely to follow. The index finger should next be carried up along the inner surface of the sac until the seat of constriction is reached at its neck, when the hernia bistoury is slid flatwise along the palmar aspect of the digit to the same point. Guided by the nail, it must be pushed up between the contents of the sac and its tightly-girdling neck, and then, with the short cutting edge turned upwards, it should be pressed against the stricture by the tip of the underlying finger until the resistance is felt to give way, when it should be withdrawn and the part dilated. In incising a stricture situated at Hey's ligament, the sac or its contents, when opened, can be kept out of the way of injury by the fingers of one hand, while the probe-point of the knife is insinuated beneath the edge of the constricting fascia with the other. A very ingenious hernia bistoury has been devised by Dr. Allis, of this city, which renders the operation for relieving the stricture one of entire safety. It is a probe-pointed knife, having a movable sheath

which can be slid up and down by means of a nut, concealing or exposing a cutting edge at pleasure. (Fig. 318.) It is introduced beneath the constriction as a flat probe, no part of the edge being visible, and after it is properly placed the operator retracts the sheath by turning the screw which

FIG. 318.



Allis's hernia bistoury. *Fig.* 1, the bistoury complete; *Fig.* 2, *a*, the blade detached from its cover, *c*; *b*, the nut which moves over the thread at the end of the cover, *c*.

is placed at the junction of the blade and the handle, cuts the stricture, and again restores the cover to its original position, when the knife can be safely withdrawn. Whatever instrument is employed to release the strangulation, the incision must be executed so as to avoid important blood-vessels, directions for which will be given under the special forms of hernia.

After relieving the constriction and finding the parts in a proper condition, the surgeon proceeds to restore them to the cavity of the abdomen. If the sac has not been opened, this is effected by simply compressing its walls between the thumb and fingers. When the sac is opened, and both intestine and omentum are present, one should be returned before the other, the intestine having precedence. This is best done by first drawing down and straightening the bowel, compressing its sides together to displace any air which may be present, and then pushing it by installments through the mouth of the sac with the finger of one hand, while with the other hand another portion is made to approach the canal. In the same manner one fold after another of the omentum is restored, and as the last piece disappears from the sac the finger should follow it the entire length of the hernial passage in order to ascertain if the canal is free. In all these manipulations the greatest gentleness should be practiced and every movement made with a distinct object in view. The fingers should be smeared with pure cosmoline, that their contact with the bowel may be rendered as harmless as possible. The operator should also be careful, in his efforts at reduction, that the sac and its contents are not pushed up together, constituting restoration "in mass." Holding the sac down while its contents are pressed upon often facilitates the passage of the rupture into the body.

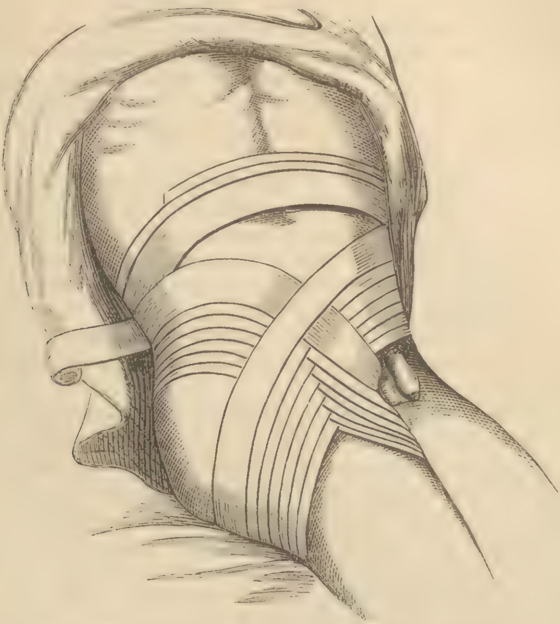
Reduction having been effected, the parts should be brought together by a few stitches of silver wire, an oiled compress placed over the wound, and the dressing made secure by a spica bandage of the groin. (Fig. 319.) The limb of the affected side is most conveniently placed by being slightly raised on a pillow laid under the knee. An anodyne may be next administered, and the bowels kept quiet for six or eight days, after which a movement may be solicited by a dose of castor oil. The diet for the first five or six days should be entirely liquid, such as milk and chicken-tea or beef-essence: if the hernial contents have been severely congested, it will be better to sustain the patient for the first few days by rectal alimentation, so that the damaged bowel, having perfect quiet, may have time to recover from the effects of the injury. As soon as the wound is sufficiently healed, the patient may rise from bed, the parts being supported by the application of a truss.

Difficulty in reduction will occasionally be encountered from a variety of conditions.

1. *Adhesions.*—These are always the result of recent or of old attacks of inflammation. These adhesions may exist between the individual loops of intestine, between the latter and the omentum when present, or between either and the inside of the sac. The uniting lymph, when of very recent

origin, is soft, and is readily broken up, but when of long standing will have the strength and consistence of well-formed bands of connective tissue. When the adhesions are found chiefly at the mouth of the sac, it is usually in

Fig. 319.



Spica of the groin, to retain dressing after operation for hernia.

cases where the vitality of the parts below has been destroyed. Such adhesions constitute a defensive work on the part of nature to prevent fæcal extravasation when the sloughs separate. When the adhesions are soft and easily overcome, they should be broken up and the parts returned; but when they are old, firm, and extensive, any attempt at detachment will be dangerous, and the surgeon must be satisfied with relieving the strangulation and allowing the hernia to remain in the sac. The same course must be adopted when the adhesions preliminary to mortification exist.

2. *Volume of the contents.*—I have seen, after division of the stricture, what seemed to be the entire small intestine, together with a large amount of omentum, enter the sac, and the bowel become so distended with air as to defy reduction. In such a case the tube should be punctured with a hypodermic needle, when after the collapse of its walls it can be returned into the abdomen.

3. *Fæcal accumulation.*—Accumulations of hardened fæcal masses may offer a serious obstacle to reduction. The difficulty may be overcome by careful manipulation, the obstruction being pressed back into the bowel above. Should this fail, the stricture should be divided and stretched to an extent which will admit of the bowel with its contents—which may be pressed into a favorable form—being passed into the body.

4. *Volvulus.*—Efforts at reduction are sometimes defeated by a loop of the intestine being twisted a number of times upon itself. Simply reversing the turns and detaching any soft adhesions which may be present will overcome this difficulty.

Complications affecting the Vitality of the Intestine.—The interference with the circulation of the intestine from a tight stricture will induce structural changes of a very serious nature.

Congestion.—The bowel, when exposed, is frequently seen in a state of ex-

treme congestion, roughened with lymph, and presenting a red, purple, or even chocolate hue, and the fluid of the sac straw-colored or blood-stained; all of which may be consistent with its vitality. When the stricture has been divided and the pressure taken from the blood-vessel, the deep shades of color will generally lighten. Should this not be the case, the parts may be covered for a few minutes with a soft piece of linen saturated with warm water, with a view to establish the circulation. If doubt still remains, the surgeon may prick the intestine with a fine needle, and if blood flows, the tube retaining its cylindrical form and its tense, elastic, and slippery feel, he has the evidence of remaining life. In all such conditions, the best place for the bowel is within the abdomen, and to this cavity it should be restored at the earliest possible moment.

Mortification.—Should the fluid of the sac have a dark, muddy appearance, the intestine remain greenish-black or black in color and without its characteristic lustre, or if its coats have become rough, ecchymosed, and softened, and emit a putrescent odor, the part is hopelessly dead and entirely unfitted for reduction. The stricture should be divided in the usual manner and the intestine freely laid open, allowing a free escape of its contents, after which the parts should be covered with a fermenting poultice or a warm water dressing. In a short time, should the patient survive, the mortified loop will separate, leaving an artificial anus.

In some instances it will be very difficult to decide the question of vitality. For example, when the bowel is of a deep congested chocolate color, which persists after the division of the stricture, when it does not recover its normal size at the point of constriction, but retains the groove or indentation made by the engirdling force, and when it creaks under pressure, it is better, the stricture having been well divided, to allow the intestine to remain outside of the abdomen, simply covering the parts with a light piece of old linen kept constantly moist with warm water for four or five hours, when the bowel should be again examined, and if the color has improved and its cylindrical form begun to return, it may be replaced just within the mouth of the sac, so that, in the event of mortification setting in, a chance may be afforded for such adhesions as shall serve to protect the cavity of the peritoneum from fæcal extravasation.

Partial mortification.—If only a very circumscribed portion of the bowel has undergone death, and presents a dark spot either open or ready to drop out, the part should be gathered up with a pair of forceps and surrounded with a fine thread, both ends of which must be cut off close to the knot, and the intestine reduced. The surgeon must decide by the security with which the encircling ligature retains its hold upon the puckered coats of the bowel, as to the extent of mortification which will admit of this treatment. When the diameter of the piece exceeds three-sixteenths of an inch, the ligature is scarcely admissible. When a portion of the bowel too large to be treated by the ligature has undergone mortification, the question naturally arises, Is it proper to return the intestine in such a state into the body? Some very excellent authorities direct in the affirmative, enforcing the propriety of not pushing the damaged gut farther than just within the mouth of the sac, so that it may become attached to the parietes of the abdomen before the slough separates. I cannot coincide with such a view: the practice is a dangerous one, and will be likely to result in the loss of the patient's life. There can be no certainty that the bowel will remain at the opening of the hernial sac; consequently there will be great risk of fæcal extravasation. A better course is to pass a fine silver thread through the walls of the intestine slightly beyond the line of demarkation, after which the knuckle should be restored to the abdomen, with the exception of the diseased portion, which must be retained by the ligature at the neck of the sac. When the dead part becomes detached and the sides of the resulting opening contract adhesion to the surrounding tissues, the thread can be removed.

A strangulated hernia may be neglected, or efforts at reduction continued from time to time, in the vain hope of avoiding the knife, until a slough forms in the walls of the intestine, in consequence of which the overlying soft parts become inflamed and ulcerate, forming a stercoraceous abscess. Should the contents of the bowel escape into the tissues exterior to the sac, the subcutaneous cellular tissue is rapidly necrosed, the skin becomes green and yellow, and the parts crepitate under pressure, from the gases which are liberated in the process of decomposition. In such conditions a free incision must be made through all the superincumbent layers of tissue into the bowel. An artificial anus is likely to follow. In a case of femoral hernia in which the strangulation had continued unrelieved for seven days, I found, from the appearance just described, that the bowel had given way. An opening was made, and, as the fæces were flowing freely, the stricture was not divided. The wound gradually granulated, and finally closed, the evacuations resuming their natural route through the rectum. This could have occurred only by the agglutination of the contiguous walls of the intestinal loop, their subsequent ulceration establishing a direct communication between the two. This case is by no means unique; a sufficient number have come under the observation of surgeons to render a similar termination quite possible under like circumstances.

Complications affecting the Omentum.—The omentum is subject to the same accidents as the intestine. It may be congested, in which case the linear arrangement of its vessels and its distended veins will be apparent, but their color is never as purple as that presented by a strangulated intestine. Such a condition, however, does not preclude its reduction. As the intestine may be enwrapped in the omentum, or even pass through an opening in its substance, a careful unraveling of the two should always be accomplished before returning either. In old herniæ the omentum is prone to become, from inflammatory and nutritive changes, greatly hypertrophied. In such a state, surgeons are very generally agreed that its reposition into the abdomen would expose the patient to the risk of peritonitis, and therefore the alternatives are presented of either allowing it to remain in the sac or of cutting it away. When the hypertrophy is slight and free from inflammation, it may be left in the sac; but when excessive, it is best to remove the diseased structure by surrounding the mass with a strong ligature close to its neck, or, if too bulky for a single cord, to draw it a little distance out so as to expose the part near to the upper ring, and transfix it with a needle bearing a double ligature, which should be tied firmly upon each half, and the mass cut off below. The ends of the ligature are to be brought out of the external wound, and retained sufficiently tight to hold the stump at the neck of the sac until the portion below the threads sloughs off, when they will come away with the latter. The stopper thus formed becomes useful in fortifying the canal against subsequent protrusions.

Mr. Holmes says that of twenty cases of hernia at St. George's Hospital in which the omentum was removed, a few died, but the examination after death showed that the fatal result was not attributable to the ligature of the omentum. Of eleven cases in which the omentum was allowed to remain in the sac, the majority recovered, notwithstanding abscess and sloughing occurred in some of them. It would seem, therefore, that though the omentum, when exposed to irritation, is, like all fatty tissues, prone to inflammation and suppuration, these processes have little tendency to extend by continuity of structure after traumatic injuries such as the ligature or retrenchment by the knife.

The omentum does not possess by any means the same capacity to resist congestive and inflammatory attacks that the intestine possesses. For this reason it is not unfrequently found unfit to reduce when the intestine is uninjured.

The omentum may be the seat of serous or sero-sanguinolent cysts, formed in its connective tissue, and also around the walls of one of its veins. When

the cysts are quite small, and when the omentum in which they are developed is in a condition to be returned, they should not be meddled with; but when large, they may be punctured and the fluid discharged.

In all cases where the intestine or the omentum is not returned into the abdomen, or is retained at the mouth of the sac, the external wound must not be closed, since it is important to have a free, dependent drainage-tract and thereby divert all inflammatory products from the cavity of the peritoneum. The parts should be covered with a carbolated water-dressing, or with a fermenting poultice.

Hemorrhage.—The vessels which are particularly likely to be cut in the operation for strangulated hernia are the epigastric and the obturator. A number of such accidents have been recorded by Lawrence, but they could have occurred only as the result either of anatomical ignorance or of recklessness. In the event of such a blunder being committed, it would be necessary to expose the vessel and secure it by a ligature.

Prognosis.—The prognosis in cases of strangulated hernia subjected to herniotomy must be based upon a variety of considerations. Among these the most important are, the duration of the strangulation, the extent to which taxis has been practiced, the treatment of the sac, and the condition of the hernial contents. The age of the patient, the duration of the rupture, the integrity of life-organs like the kidneys and lungs, and the form of the rupture, must also be taken into account in conjecturing the probable issue after such an operation.

Time is a matter of great moment to a person suffering from strangulated hernia. The chances of recovery after seventy-four hours rapidly diminish. The bulk of the rupture and its contents will serve to lessen somewhat the evil effects of time, as large herniæ, and those in which both intestine and omentum are present in the sac, suffer less from strangulation than those in which the rupture is small and the contents consist of either the bowel or the omentum alone. This is due to the fact that the extensive dilatation of the hernial passage renders the circulation less precarious. Mr. Gay* has tabulated one hundred and eighteen cases which show the effect of time on the mortality of strangulation.

	Cases.	Recoveries.	Deaths.
First day	49	43	6
Second day	41	30	11
Third day	9	3	6
Fourth day	5	2	3
Fifth day	4	0	4
Sixth day	7	3	4
Tenth day	3	0	3
Total	118	81	37

Rude and prolonged efforts at reduction greatly diminish the prospects of a patient's recovery after herniotomy. I have constant occasion to deplore the well-meant mistakes which are thus committed by practitioners. It would be well if every professional man could be made to feel that every minute over ten which he consumes in vain or badly-applied attempts to return a strangulated bowel involves danger to the life of his patient.

As an evidence of the injurious effects of prolonged taxis, M. Boyer† states that for five years, when his practice was to make long-continued efforts at reduction, eight cases out of nine operated on proved fatal. During the next five years, when he employed taxis to a more limited degree, four out of seven died; and in the course of the succeeding five years, after almost entirely abandoning the use of this manipulation, he saved ten out of fourteen cases. M. Manec,‡ who usually proceeded to the operation without resorting to taxis, saved twenty-six out of twenty-eight patients.

* Gay on Hernia. † Revue Méd.-Chirurg., 1847. ‡ Ibid., 1847.

When the surgeon is forced to open the sac, another factor is introduced, which seriously complicates the cure and increases the fatality of herniotomy, as already shown.

When either the intestine or the omentum has been damaged in its vitality to such a degree as to render it unfit to be returned into the body, the danger to life is very great, either from peritonitis, or more remotely, should the patient survive, from the effects of an artificial anus.

The young are more likely to recover after herniotomy than the aged. The influence of age upon the result of operations for strangulated hernia is shown in the following analysis of a collection of three hundred and fifty-seven cases :*

Age.	Total operated on.	Recovered.	Died.
Under 1 year	2	2	....
Between 1 and 10 years	3	3	....
" 10 and 20 "	7	6	1
" 20 and 30 "	55	36	19
" 30 and 40 "	51	32	19
" 40 and 50 "	63	40	23
" 50 and 60 "	73	52	21
" 60 and 70 "	60	32	28
" 70 and 80 "	30	17	13
" 80 and 90 "	11	6	5
" 90 and 100 "	...	....	....
Above 100 years	2	2	....
Total	357	228	129

The earliest age at which the operation for strangulated hernia has been done, so far as I can learn, is that of the case by Dr. Thomas H. Andrews, of this city. The patient was forty-five hours old, and made a rapid recovery.†

A hernia of recent origin, should it demand an operation, is more likely to terminate fatally than one of long standing. This is easily explained, since the orifices through which the rupture suddenly descends have not been subjected to much dilatation, and therefore exercise a dangerous degree of constriction upon the contents of the sac.

Certain herniæ, the femoral and the umbilical, are less tolerant of operation than others, and consequently more prone to a fatal end.

The value of sound kidneys and other life-organs, both in the abdomen and in the thorax, to a successful herniotomy, as well as to other capital operations, cannot be over-estimated. A defect in these may turn the scales adversely to the patient when all other circumstances tend to recovery.

In the last eighteen years 324 persons are reported to have died in the city of Philadelphia‡ from strangulated hernia. If we compare with this mortality that from all causes for the same period, about 352,000, we shall find that there has been a fraction less than one death from strangulated hernia to every thousand from all other diseases combined.

In most instances death is caused by general peritonitis, excited by the local irritation of the stricture, by unskillful manipulation, and by fæcal extravasation. In some cases, especially when the subject is advanced in life or broken in health, death ensues from shock; and in a few instances, as when an artificial anus is established, it may be the result of exhaustion from defective nutrition.

* Hancock on Strangulated Hernia, p. 90.

† Philadelphia Medical Times, vol. vi. p. 151.

‡ From a manuscript report of cases of death from strangulated hernia, furnished to me by Dr. Wm. H. Ford, Secretary of the Board of Health, Philadelphia.

Special Herniæ.

The most common varieties of hernia are *inguinal*, *femoral*, and *umbilical;* in addition to which may be mentioned the rarer forms of the disease, namely, the obturator, sciatic, perineal, vaginal, pudendal, ventral, and diaphragmatic.

Inguinal Hernia.

Inguinal hernia constitutes a large proportion of the different varieties of the disease, at least sixty-six per cent. It is more common in males than in females, is oftener found on the right than on the left side, and constitutes more than one-half of all the cases of strangulation.

There are two forms of inguinal hernia: the indirect or oblique, and the direct or ventro-inguinal.

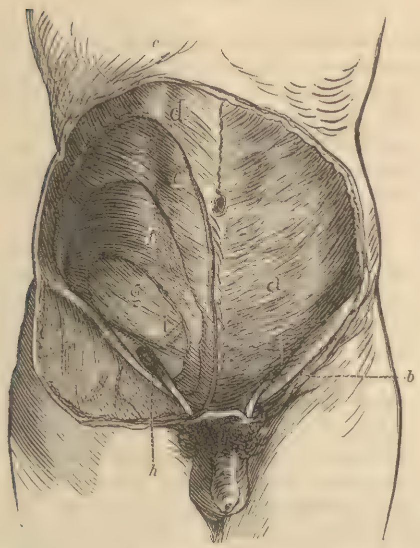
Surgical anatomy.—A brief enumeration of the anatomical components of the inguinal region will materially assist the reader in practically understanding the subject. Let it be remembered that a hernia in passing from the interior to the exterior of the body follows the course of certain blood-vessels, carrying before it a layer of all the intermediate structures, and that these structures constitute its "coverings." Inguinal hernia follows the spermatic vessels or the spermatic cord.

The leading anatomical points to be considered are as follows:

The external abdominal ring is a triangular space situated in the tendon of the external oblique muscle, one branch of which is implanted upon the tuberosity and the other upon the crest of the pubic bone, constituting what are termed by anatomists the "pillars" or "columns" of the ring. From the edges of these pillars is prolonged a membranous structure,—the intercolumnar fascia,—which closely invests the cord as it passes into the scrotum. The different strata of tissues composing the abdominal parietes above Poupart's ligament are arranged in the following order: skin, superficial fascia, tendon of the external oblique, of the internal oblique, and of the transversalis muscles. Underneath the last-named muscle lies the cord, resting upon the transversalis fascia, which separates it from the peritoneum. Two inches above the external ring, and one inch above the middle of Poupart's ligament, the cord makes its appearance, coming apparently through an opening in the fascia transversalis. This apparent opening is the "internal ring." If the cord be drawn outwards and downwards it will be seen that the transversalis fascia, like the intercolumnar fascia at the external ring, is continued downwards over the spermatic cord as a funnel-shaped prolongation, the "infundibuliform fascia." The space between the internal and external rings is the "inguinal canal." At the posterior wall of the internal ring, behind the cord and running upwards and inwards, are situated the deep epigastric blood-vessels. The internal ring being situated at a greater distance above Poupart's ligament than the external, the space between the two is necessarily oblique in its direction. (Fig. 320.) A hernia which enters the internal ring, passes along the canal, and presses its way through the external ring, descending into the scrotum or into the labium, is called a *complete oblique inguinal hernia.* The coverings of such a hernia consist of the different layers forming the abdominal walls; that is, considered from without inwards, they are skin, superficial fascia, intercolumnar fascia or the tendon of the external oblique, the internal oblique, and the transversalis muscle, or "cremaster,"—the latter consisting of fibres derived from the other two,—the transversalis or infundibuliform fascia, and, finally, the peritoneum or sac. In many cases of inguinal hernia the transversalis or infundibuliform fascia does not form a covering, as it gives way before the descent of the bowel. When a hernia enters the inguinal canal through the internal ring, but does not pass out through the external ring, it is called an *incomplete inguinal* or *concealed hernia.* The coverings of this form of rupture are the same as those which belong to the

complete variety. It often happens that the intestine or omentum, instead of following the indirect course of the canal, presses directly out through the external abdominal ring into the scrotum, forming another variety of rupture,—the *direct* or *ventro-inguinal.* (Fig. 321.)

Fig. 320.



a, tendon of the external oblique muscle with the external abdominal ring and cord; *b*, *c*, skin and superficial fascia; *d*, tendon of the external oblique; *e*, *f*, internal oblique and transversalis or cremaster muscle; *g*, transversalis or infundibuliform fascia with the cord passing through the internal ring, *h*, behind which lies the epigastric artery, *i*.

Fig. 321.

a, oblique inguinal hernia; *b*, direct or ventro-inguinal hernia; both having descended into the scrotum.

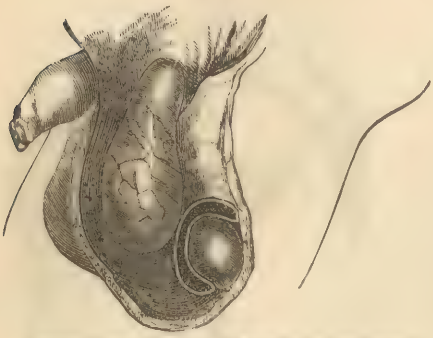
It is not always easy to determine whether an inguinal hernia is oblique or direct. If the tumor is large, the internal ring is dragged down to the external one, so that when the hernia is reduced and followed by the finger the latter seems to go directly into the abdomen. Females are said to suffer rarely from the direct form of the disease. There is a difference of opinion in regard to the coverings of this last-named hernia. Into the front of the linea ilio-pectinea of the pubis, directly behind the external ring, is inserted the conjoined tendon of the internal oblique and transversalis muscles. Some writers accordingly regard this tendon as constituting one of the investments of the rupture in question. This, however, is not the case, as the protrusion passes round the outer edge of the conjoined tendon. The coverings differ from those of the other forms of inguinal hernia only in the absence, in a great measure, of the fibres of the cremaster muscle, the latter being, with the cord, pushed to the outer side of the ring as the hernia passes through into the scrotum.

Many persons suffer from inguinal hernia on both sides. The size of the swelling varies much in different cases. It may be so small as scarcely to be recognized, and it may be so voluminous as to extend almost to the knees. There are not wanting instances in which both indirect and direct hernia existed in the same person on the same side. In cases of oblique inguinal hernia accompanied with an undescended testicle, that is, where the gland lies in the inguinal canal, the former will sometimes lie in a position very different from that occupied where no such complication is present; the obstruction presented by the testis in front forces the rupture, in order to obtain room, out towards the spinous process of the ilium, and, when the protrusion is large, even down over Poupart's ligament upon the thigh. This forms the *intraparietal hernia* of some writers.

In a young man on whom I operated for a strangulated hernia, the testicle was first encountered occupying the principal part of the canal, above which was found the bowel turned directly back, the sharp flexion of which appeared to constitute the cause of the constriction.

Scrotal Hernia.—When either a direct or an indirect inguinal hernia passes through the external abdominal ring and enters the scrotum, it is called a scrotal hernia. In such a rupture the sac—formed from the parietal peritoneum—and its contents are placed anterior to the tunica vaginalis, with the testicle near the bottom of the scrotum. (Fig. 322.)

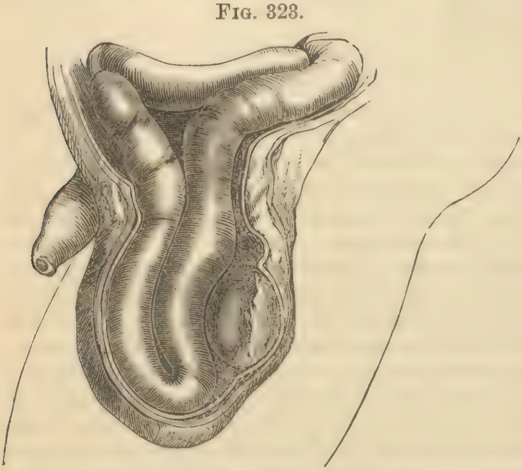
FIG. 322.



Inguinal scrotal hernia; its relation to the tunica vaginalis and testicle.

Three other forms of scrotal hernia are met with, which owe their existence to peculiarities in the vaginal process of the peritoneum accompanying the testicle in its descent from the loins into the scrotum, forming the tunica vaginalis testis. The first is commonly known as *congenital hernia*, and is due to the fact that the vaginal process does not contract around the cord and thus cut off communication between the cavity of the abdomen and that of the tunica vaginalis. Accordingly, the two cavities being continuous, the intestine passes down and lies in contact with the testicle (Fig. 323), or may descend, leaving the latter within the canal, or even in the abdomen. The second form, called *infantile hernia* (though it is also seen in persons of mature age), is caused by the upper or abdominal portion of the vaginal process, sometimes called the funicular process, remaining open, while the lower part, or that near the external ring, is closed. The hernia enters the funnel-like process thus formed, and, pushing it gradually downwards until it is protruded into the scrotum, fashions for itself a sac distinct from the tunica vaginalis, the testicle being below with an independent covering. (Fig. 324.) The third variety is the *encysted hernia* of Cooper. This rupture is produced by the vaginal process closing at the internal but remaining open at the external ring. The hernia pushes before it the parietal peritoneum as in the formation of an ordinary rupture, and carries it gradually downwards until it is protruded into the unclosed tunica vaginalis below, forming in this way two sacs. (Fig. 325.) This variety of the disease was termed by Hey, infantile hernia.

FIG. 323.



Congenital hernia, showing testicle and hernia in the same sac.

Hernia in females.—The forms of inguinal hernia which occur in females, and the coverings, are the same as those in males. The round ligament occupies, in the canal, the place of the spermatic cord in the male, and the labium the place of the scrotum.

DIAGNOSIS.—There are a number of tumors which occur in the regions occupied by inguinal hernia and which serve in many instances to embarrass the practitioner. Some of these can be made to appear and disappear by

FIG. 324.

Infantile hernia, having the funicular process as its sac.

FIG. 325.

Encysted hernia.

position or by pressure, which circumstance enhances the difficulty of diagnosis. There are three kinds of swellings which resemble inguinal hernia. These may be generalized as the *reducible*, the *irreducible*, and the *mixed*. The reducible swellings are varicocele, congenital hydrocele, and hydrocele of the funicular sheath of the cord.

The irreducible swellings are hydrocele and hæmatocele of the vaginal tunic, sarcocele, undescended testicle, enlarged glands, and abscess.

The reducible swellings which simulate inguinal hernia.—The first to be noticed is *varicocele*, and the points of likeness and dissimilarity may be contrasted as follows:

INGUINAL HERNIA.	VARICOCELE.
In inguinal hernia the swelling occupies the scrotum.	In varicocele the swelling occupies the scrotum.
The swelling appears in the erect, disappears in the recumbent position.	The swelling appears in the erect, disappears in the recumbent position.
Distinct impulse on coughing or in straining.	Faint impulse on coughing or in straining.
Round or oval in form, having a smooth, uniform surface and an elastic feel.	Elongated in form; irregular in surface; a soft, doughy feel, with the sensation like that of interlacing or contorted cords.
The skin unaltered in color.	The skin often having a blue color, in consequence of the proximity of the dilated veins to the surface.
When reduced in the recumbent position, and the patient rises to the erect position, the swelling reappears first at the upper part of the scrotum, gradually descending to its bottom.	On rising to the erect position after recumbency, the swelling reappears first at the bottom of the scrotum, gradually rising towards the abdomen.
When reduced and a finger is placed over the external ring, neither coughing, straining, nor standing will cause the tumor to appear in the scrotum.	When reduced and a finger is applied with *moderate* pressure over the external ring, the swelling will quickly reappear.

The presence of omentum as a constituent of the hernial sac may cause it slightly to resemble varicocele, but the feel of the soft fatty tissue of the former is very different from that of the latter, and the impulse which hernia communicates on coughing is quite unlike that received from a bundle of veins and the slight distention produced by any force transmitted through the abdominal contents.

Congenital hydrocele may occupy either the tunica vaginalis testis or the funicular sheath of the cord; and in distinguishing hernia from either of these conditions the following considerations will aid in establishing the proper diagnosis:

INGUINAL HERNIA.	CONGENITAL HYDROCELE.
Reducible by taxis or the horizontal position, disappears suddenly, and generally with a gurgling sound.	Recedes slowly and silently.
Is not translucent by the light test.	Is translucent by the light test.

More difficulty may be experienced in distinguishing the hernia from encysted hydrocele. The fluid in the latter may be pressed into the inguinal canal, or, if confined to the canal, can be pressed up to its summit and out of sight, just as a hernia may be; but hydrocele, on the removal of this pressure, or upon the cord being grasped below the external ring, and without straining or coughing on the part of the patient, will quickly reappear. Such will not be the case with a hernia.

The irreducible swellings which resemble inguinal hernia.—The first swelling to be noticed is *hydrocele*. This is a very common disease, but can be readily distinguished from hernia by the following peculiarities:

HERNIA.	HYDROCELE.
Commences above and descends into the scrotum.	Commences below and rises upwards.
The cord cannot be felt when the hernia is in the scrotum.	Between the external ring and the top of the hydrocele the cord can be felt.
Impulse communicated in coughing or straining.	No impulse experienced.
Reducible.	Non-reducible.
Opaque by light test.	Translucent by light test.
Hangs to the body.	Stands off from the body.
No fluctuation.	Fluctuation.

In consequence, generally, of an injury, a collection of blood may form in the cavity of the tunica vaginalis, constituting a *hæmatocele*. How shall we avoid confounding it with hernia?

HERNIA.	HÆMATOCELE.
History of an injury not usually present.	Generally the history of an injury.
The tumor is soft, offering little resistance to pressure.	Firm and resistant.
Tumor moderately heavy.	Markedly heavy.
Admits of impulse.	No impulse.
Skin natural.	Skin often discolored.
Cord concealed by the tumor.	Cord free and easily grasped.
Exploration by the grooved needle reveals no blood.	Grooved needle reveals blood.

Sarcocele, or enlargement of the testicle, has really, except in position, few points of resemblance to scrotal hernia. Yet the diseases are often confounded with each other. The following considerations will serve to establish the lines of difference:

INGUINAL HERNIA.	SARCOCELE.
Always a reducible tumor at some stage of its history.	Always irreducible.
The inguinal canal occupied, and the cord concealed.	The canal unoccupied, and the cord free.
Impulse on coughing.	No impulse on coughing.
Tumor light.	Tumor heavy.
Tumor soft.	Tumor hard.
Tumor has a uniform surface.	Tumor has an uneven surface.

An *undescended testicle* may be mistaken for hernia. The resemblance between the two is increased in those instances where the gland is unstable in its position, becoming the sport of the cremaster muscle and of the gubernaculum; and where sometimes it is found in the upper part of the scrotum, and at other times in the inguinal canal. Two or three differential points will remove all obscurity in such a case:

INGUINAL HERNIA.	UNDESCENDED TESTICLE.
Testicle in the scrotum.	Absence of the gland from the scrotum.
Soft in consistence.	Hard in consistence.
Firm pressure causing no peculiar pain.	Firm pressure giving rise to a sickening pain.

There are cases in which the canal contains both a hernia and a testis. The latter is in advance of the former; and pressure will determine which is the gland.

Situated above Poupart's ligament, a little below the internal abdominal ring, are one or two *lymphatic glands*, which, by one not altogether familiar with tumors in this region, might be regarded as an incomplete hernia. The differential features of the two are as follows:

INGUINAL HERNIA.	ENLARGED INGUINAL GLANDS.
No history of a previous disease, such as gonorrhœa or syphilis, or of a local irritation in any part of the lower extremity.	Usually traceable to a local irritation, or to a constitutional state.
Direction of the tumor in the long axis of the inguinal canal.	Direction of the tumor oblique to the long axis of the canal.
Admits of little movement at any time, and lies deep.	In its commencement quite movable, and is superficial in position.
Devoid of any great sensibility.	During the acute stage of the enlargement is very sensitive and painful.
Generally reducible.	Not reducible.
Uniformly soft in consistence, and the superincumbent skin of a natural color.	At first hard, afterwards becoming soft; the skin in the early stage often of a red color and œdematous.

In a number of instances I have seen an *abscess*, having its origin in the lumbar vertebræ, find its way between the muscular planes of the abdomen and form a prominent swelling in the course of the inguinal canal. This swelling is diminished by the recumbent position or is susceptible of being reduced in size by pressure, and, when manipulated, may yield a peculiar sound. These facts give to such an abscess some of the signs of incomplete hernia. The distinction may be determined by attention to the following points:

INGUINAL HERNIA.	ABSCESS.
Occurs in persons of unimpaired health, and without previous or premonitory symptoms.	Occurs in persons usually having a constitutional vice, and who have long suffered from soreness, pain in the loins, accompanied with loss of flesh, and with hectic symptoms.
Without fluctuation.	With fluctuation.

In addition to the affections now enumerated, *fatty tumors* are occasionally encountered in the canal, more or less connected with the cord; or the cord itself may become inflamed and thickened, in either case forming a swelling which occupies exactly the position of an incomplete hernia. The irreducibility of such tumors, the absence of a distinct impulse, and the difference in consistence,—being doughy in fatty growths and very hard in inflammatory disease of the cord,—will serve to distinguish such from rupture.

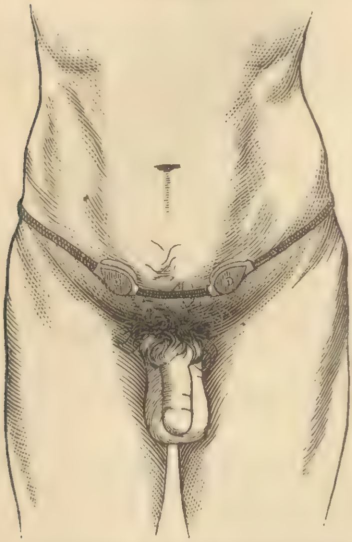
Treatment.—Inguinal hernia, whether incomplete or complete,—that is, whether in the inguinal canal, in the scrotum, or in the labium,—if reducible, should be restored to the abdominal cavity, and there retained by a carefully-adjusted truss, the pad of which should be so placed as to compress the entire canal. A very common error committed in the application of a truss is that of bringing the pad so low as to rest on the pubic bone, and consequently, in bending, the surface of the abdomen corresponding to the inguinal passage recedes from the pad and allows the hernia to escape. The instrument as modified by Mr. Gemrig (Fig. 326), having a bearing on both inguinal regions (though lightly on the sound side), is not liable to change its position, and the posterior pads resting on the fleshy portions of the pelvis on either side of the sacrum are connected by a strap having a number of holes, by which the truss can be tightened or relaxed. (Fig. 327.)

The hard-rubber truss is likewise well suited for the treatment of inguinal

hernia. The best patterns are those represented in Figs. 328, 329, and 330.

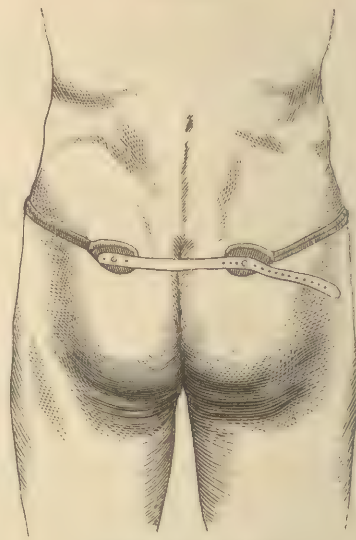
In the application of the rubber truss to an inguinal hernia of one side, two patterns are employed,—one in which the spring and the pad cross over

FIG. 326.



Truss adjusted to a case of inguinal hernia.

FIG. 327.

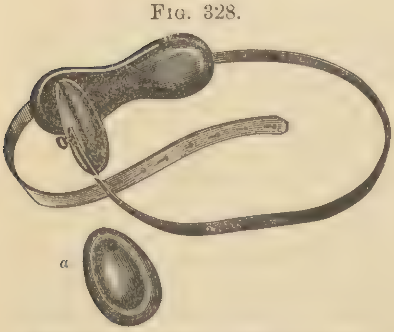


Posterior view of the truss.

from the sound to the affected side (Fig. 331), and the other in which the spring and the pad come round the side on which the rupture is situated. (Fig. 332.) When the hernia is double, a pad is attached to each extremity of the spring, and when the truss is applied, a strap extends from one pad to the other, in order that the instrument may keep its place securely. (Fig. 333.)

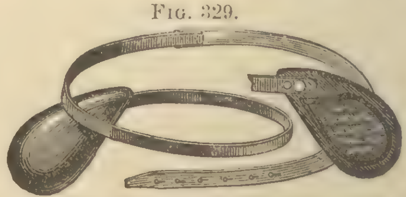
Irreducible inguinal hernia, when in the scrotum, requires the use of a

FIG. 328.



Hard-rubber truss for single inguinal hernia.

FIG. 329.



Rubber truss, without the dorsal pad.

FIG. 330.

Rubber truss for double inguinal hernia.

suspensory bandage,—a dressing which greatly relieves the weight and dragging sensations so often complained of by patients suffering from large herniæ, and also resists, in some degree, an increase in the protrusion. When

the hernia remains in the canal and is irreducible, a truss with a concave pad (Fig. 328, *a*) may be worn with advantage, in the use of which the surgeon should see that the concavity is ample enough not to press injuriously upon

FIG. 331.

Truss applied to an inguinal hernia and crossing over from the sound to the affected side. Below, same truss, detached.

FIG. 332.

Truss applied to an inguinal hernia from the affected side.

the tumor. Infants having hernia form no exception to the rule requiring an early application of a truss. If the instrument is properly fitted, and if the surface of the skin upon which the pad rests is well rubbed with alcohol and afterwards dusted with prepared chalk or with lycopodium, no apprehension of excoriation or of ulceration need be felt. It is in this class of patients that a cure may be confidently expected, and hence the necessity for an early resort to the instrument.

Strangulated inguinal hernia.—When the hernia becomes strangulated and cannot be restored by taxis, an operation will at once become necessary. The hair should be shaven from the pubes on the affected side, the urine removed from the bladder, and an incision made, extending from the external ring almost to the lower extremity of the tumor. The different layers of tissue constituting the coverings of the hernia should be raised upon the director and divided to the full extent of the external or tegumentary wound, securing at the same time any vessels which may spring. It is very improbable that the operator will be able to lift the stratifications of tissue in the order usually described, and if he could do so it would prove of little value. He will, however, be always able to recognize one of these coverings,—the cremaster muscle, which is separated from the sac only by some connective tissue, so that when this muscle is reached he should proceed with increased caution. When the hernial sac has been laid bare, the next step consists in ascertaining the situation of the stricture and dividing it sufficiently to admit of the reduction. In oblique inguinal hernia the stricture will be found in the cellular tissue external to the neck of the

FIG. 333.

Truss applied for double inguinal hernia.

sac, commonly described as the internal ring, at the inner surface of the neck of the sac; and it is said that it may be at the external ring, or under the edge of the internal oblique and transversalis muscles. According to my own observation, it is generally situated either at the internal ring or at the neck of the sac. Where it is possible, the surgeon should effect reduction without opening the latter. In dividing the stricture, the knife must be guided flatwise upon the finger, and when it is fairly underneath the resisting band it should be turned so that it will lie exactly *parallel with the course of Poupart's ligament*, after which its edge should be directed against the constriction and pressed by the underlying digit *directly upwards*, in order to avoid wounding the epigastric artery, which lies behind and to the inner side of the hernia.

Should symptoms of strangulation be present without any visible tumor, and there be grounds to suspect the existence of a concealed or an incomplete inguinal hernia, the surgeon should have no hesitation in laying open the canal in order to verify or to disprove its existence. In such a case the incision should be made over and in the course of the inguinal canal, beginning one inch above the middle of Poupart's ligament, and extending into the external ring. The skin, superficial fascia, tendon of the external oblique, and some of the fibres of the internal oblique and transversalis muscles, will require to be divided, when the internal ring will be exposed and the rupture, if present, detected.

Should the case be one of direct or ventro-inguinal hernia, the stricture must be sought for at the external abdominal ring, or at the edge of the "conjoined tendon;" and in dividing it, the edge of the bistoury should be directed *upwards and slightly inwards*, to avoid the epigastric artery, which lies external to the rupture.

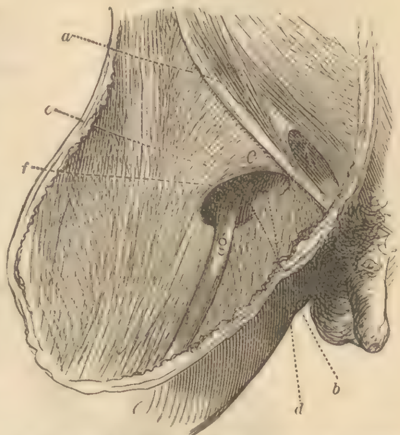
Femoral Hernia.

In femoral hernia, the intestine, omentum, or both, pass from the abdomen beneath Poupart's ligament, and appear at the inner and anterior portion of the thigh. When the tumor is large, it will frequently be found to lie parallel with Poupart's ligament, and sometimes to turn over that structure and rest upon the lower part of the abdomen.

Anatomy.—When the skin and superficial fascia are removed from the front of the thigh, below Poupart's ligament, the fascia lata will be exposed. Resting upon this strong muscular envelope is the internal saphenous vein, which, a short distance below Poupart's ligament, disappears from view in the midst of a loose mass consisting of inguinal lymphatic glands, fat, and connective tissue. Through this tissue also pass the superficial epigastric, the superficial circumflex iliac, and the superficial pudic arteries and veins; also numerous lymphatic vessels from the subcutaneous portions of the thigh, abdomen, and generative organs. The effect of so many structures entering and passing out at this point is to cause numerous perforations in the fascia, and hence this mass of glandular and connective tissue is termed the *cribriform* fascia. When the fascia is carefully cleared away, a peculiar opening—*saphenous*, or like the figure 6—is exposed in the fascia lata, at the bottom of which opening lie the femoral vessels inclosed in their sheath, and through which passes the saphenous vein in order to empty into the femoral. That portion of the fascia lata which is external to the saphenous opening is the *sartorial*, and that part which is internal to this orifice is the *pectineal* fascia. The inner border of the outer or sartorial portion is crescentic or sickle-shaped, and is called the *falciform process*, the upper extremity of which, connected to and folded beneath Poupart's ligament, constitutes *Hey's ligament*. (Fig. 334.) The space between Poupart's ligament and the innominate bone is the *crural arch*. At the inner or pubic extremity of this arch the ligament is attached some distance back along the linea ilio-pectinea, forming a strong crescent-shaped membrane, *Gimbernat's ligament*, its concavity looking outwards.

Passing through this crural arch, and enumerated from without inwards, are the iliacus internus and psoas magnus muscles, between them the anterior crural nerve, and inside the femoral artery and the femoral vein. It so happens that the femoral vein does not quite reach to the inner boundary of the crural arch, or, what is equivalent, to Gimbernat's ligament, in consequence of which a weak point exists at this place, to which the name *femoral ring* is applied. This ring is therefore situated between the femoral vein and Gimbernat's ligament, and it is through this space that a femoral hernia descends from the abdomen to the thigh. It is not possible for the protrusion to occur at any other part of the crural arch.

FIG. 334.



a, Poupart's ligament; *b*, saphenous opening, beneath the external abdominal ring; *c*, sartorial fascia; *d*, pectineal fascia; *e*, Hey's ligament; *f*, falciform process; *g*, saphenous vein, entering the femoral vein.

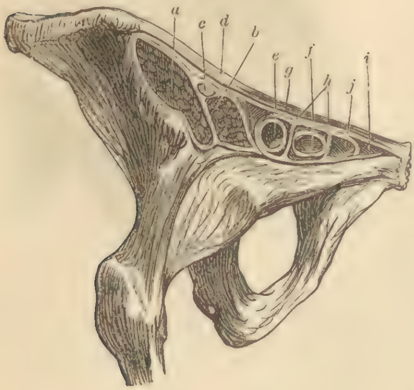
One not familiar with the anatomical provisions of this part of the pelvis might ask, Why cannot a hernia pass out at any point between Poupart's ligament and the structures which fill the crural arch, or behind these and the innominate bone? The answer to this question is as follows:

Between the peritoneal sac which contains the intestines and the muscles which lie in front and behind, viz., the abdominal and the iliacus internus and psoas magnus, is interposed a fascia, which anteriorly is called the *transversalis*, and posteriorly the *iliac*. These two unite along the inner surface of Poupart's ligament, and thus render it impossible for any of the abdominal viscera to slip through beneath the ligament and that part of the crural arch which is occupied by the psoas and iliacus internus muscles. The space internal to these muscles is that portion appropriated to the passage of the blood-vessels, and may be called the vascular part of the crural arch, in contradistinction to the other, the muscular part. The transversalis and iliac fasciæ, which along the muscular portion of the arch are attached to Poupart's ligament, divide when they reach the vascular part, the iliac passing out upon the thigh behind and the transversalis in front of the blood-vessels, thus forming a sheath for the femoral artery and vein as they lie in the saphenous opening. To prevent any of the abdominal contents from reaching the thigh, either in front of or behind the vessels, two strong membranes pass from Poupart's ligament and the vascular sheath in front to the iliac fascia or the sheath behind,—one between the artery and the vein, and the other on the pubic or inner side of the vein. We are thus brought to the little space between the femoral vein and Gimbernat's ligament,—*the femoral ring*,—which alone remains unfortified, and where alone visceral escape, except in very rare instances, is possible. Fig. 335 will furnish an explanation of the anatomical structures described in the text. Above the femoral ring an important artery—the obturator—is frequently met with. Though such is an anomalous position for this vessel, it is a very common distribution, occurring in about one out of every three cases, and should be remembered in all operations for strangulated femoral hernia, as in the course of the vessel from the epigastric to the obturator foramen, through which it passes to the thigh, it is exposed to injury in the act of dividing the stricture. The neck of the sac of a female hernia is also related to the epigastric artery and to the spermatic cord, the first being on its outer side, and the last above and to the inner side.

The process by which a femoral hernia is formed is as follows. The intestine, or omentum, or both, inclosed in the peritoneum or sac, are impelled against the inner part of the crural arch, and, meeting with little resist-

ance at the internal ring, that is, between the femoral vein and Gimbernat's ligament, gradually press through, glide underneath Poupart's ligament, following the vessels, and then, having entered the saphenous opening, come forward upon the thigh, forming a tumor or a swelling, more or less distinct, in the groin. (Fig. 336.) The *coverings* of such a hernia are the skin, the superficial fascia, the cribriform fascia, the subperitoneal cellulo-fatty tissue, sometimes called the *septum crurale*, and the sac. Some enumerate the sheath of

Fig. 335.



a, muscular portion of the crural arch occupied by the iliacus internus; *b*, psoas magnus; *c*, crural nerve, with iliac fascia in front; *d*, Poupart's ligament; *e*, femoral artery; *f*, femoral vein, with the iliac and transversalis fascia separating at the inner edge of the muscles, *g*, and passing in front and behind the vessels to form their sheath, with its vertical membranous partition, *h*; *i*, Gimbernat's ligament; *j*, femoral ring.

Fig. 336.

Femoral hernia.

the vessels, called by Cooper the *fascia propria*, as one of the investments of femoral hernia. That it ever forms one of the coverings is exceedingly doubtful. I have never witnessed in my operations for strangulated femoral rupture anything which resembled this structure; and when it is considered how very frail is the connection of the vascular sheath with Gimbernat's ligament, it is easy to understand how it must give way and allow the hernia to pass down.

Femoral hernia occasionally deviates from the course which has been described. The tumor may remain in the saphenous opening without entirely displacing the cribriform fascia or coming forward upon the thigh; in which case it is called an *incomplete femoral hernia*,—analogous somewhat to the inguinal form of the disease which remains in the inguinal canal and is called incomplete inguinal hernia. Cloquet has described a rare variety of this rupture, in which the intestine passes behind the sheath of the vessels, or between the latter and the pectineus muscle; and Partridge, one where the protrusion takes place on the outside of the vessels. Hesselbach also speaks of a multilobular form, caused by portions of the sac passing through different openings in the cribriform fascia. So rare, however, are these varieties of femoral rupture that they are to be regarded rather as surgical curiosities than as subjects of practical interest.

The contents of the sac of a femoral hernia differ very little from those of an inguinal hernia. They consist of both intestine and omentum, but in most cases not to the same extent as in the latter rupture; nor does the omentum so frequently constitute a part of the sac as in inguinal hernia.

Symptoms.—The existence of a femoral hernia is usually recognized by the presence of a firm oval swelling below Poupart's ligament, at the inner side of the thigh, and between the spine of the pubic bone and the femoral vessels.

The exact position of the protrusion is determined by the size of the hernia. When large, in consequence of the resistance encountered by the attachment of the cribriform fascia at the lower margin of the saphenous opening, the swelling will either lie transversely along the lower border of Poupart's ligament or it will turn over the latter upon the abdomen. In the last position it has often been mistaken for an incomplete inguinal hernia. Even small herniæ manifest a disposition to turn upwards over Poupart's ligament. In the act of coughing, an impulse is communicated to the tumor, and on percussion a distinct resonance can often be elicited. In some cases the protrusion does not pass through the saphenous opening, but remains in the femoral ring, and consequently makes scarcely any external appearance. When such a condition is suspected, the investigation must be made when the parts are thoroughly relaxed. This can be best effected by elevating the shoulders, flexing the leg upon the thigh, and the thigh upon the abdomen, the knee being at the same time turned towards the opposite side. If a finger be now pressed into the saphenous opening and upwards under Poupart's ligament, the hernia, if present, may be recognized by the characteristic impulse on coughing.

DIAGNOSIS.—Femoral hernia may be confounded with other affections which have their location in the groin, the most common of which are incomplete inguinal hernia, enlargement of the inguinal lymphatic glands, psoas abscess, varicose dilatation of the saphenous vein, and fatty and sarcomatous growths.

Incomplete inguinal hernia is distinguished by the following characteristics:

FEMORAL HERNIA.	INCOMPLETE INGUINAL HERNIA.
When in the usual position, Poupart's ligament can be recognized above the tumor.	Poupart's ligament is recognized below the tumor.
The form is oval or spherical, and the tumor lies transversely to the long axis of the thigh or parallel with Poupart's ligament.	The form is oblong, and the tumor lies oblique both to the longitudinal axis of the thigh and to Poupart's ligament.
When turned over Poupart's ligament, if the tumor be drawn down towards the thigh, the former can be distinctly felt by the finger in its entire course.	Should the tumor cover Poupart's ligament, it must be raised up in order that the latter shall be felt.
Femoral artery can be felt pulsating on the outer side.	Femoral artery is some distance below.
The spine of the pubis is on the inner side.	The spine of the pubis is on the outer side when the hernia is in the ring.
The neck of the tumor can be traced deep into the thigh, below Poupart's ligament.	The neck of the tumor is more superficial, and above Poupart's ligament.
Quite movable.	Not much mobility.
In the recumbent position, when the thigh is flexed on the abdomen, the mobility of the tumor is materially increased.	Under a similar position the mobility of the tumor is not materially increased.
Most common in the female.	Most common in the male.
Most common in mature life.	Common at all periods of life.

Much information may also be gained by examining the respective rings, in order to ascertain if they are unoccupied, by drawing upon the protrusion and at the same time watching the effect upon the contiguous parts, whether the tension of the soft parts is in the direction of the thigh or in that of the abdomen, and by carefully noticing the direction of the impulse, whether downwards or forwards in the course of the thigh, or downwards and inwards towards the external abdominal ring. When the herniæ which have been described are reducible, little difficulty can arise in forming the proper diagnosis, as the finger will determine the unoccupied ring, and, by commanding it, prevent the return of the tumor, either in standing or in coughing.

Enlargement of the inguinal glands has, in my experience, been more frequently confounded with femoral hernia than any other swelling in this region. The signs of the two may be contrasted as follows:

FEMORAL HERNIA.	ENLARGED INGUINAL GLANDS.
Unless strangulated, a painless tumor, without discoloration of the skin or undue sensibility to the touch.	Acute adenitis is painful, and the superimposed skin is red and sensitive to the touch.
A smooth, regular, and somewhat elastic swelling.	An irregular swelling, the individual glands of the group often being recognized by the fingers, and having a hard feel.
Pulsation of the femoral artery external to the tumor.	Pulsation of the femoral artery beneath and to the inner side of the tumor.
Impulse communicated on coughing; tumor deeply situated.	No impulse communicated on coughing; tumor superficial.
If reducible, the disappearance of the swelling effected by posture or taxis.	Not affected by position or by taxis.
Tumor rendered more fixed by extension of the limb.	Tumor not affected by straightening the limb.

Hernia and enlarged glands may coexist, in which case the diagnosis would be rendered more perplexing. If symptoms of strangulation be present in a case of enlarged glands, an exploratory incision should be made, in order to remove all uncertainty.

Psoas abscess is frequently mistaken for femoral hernia. Such an error betrays considerable anatomical ignorance, notwithstanding that there are several points of resemblance between the two diseases. For example, both tumors are below Poupart's ligament; both are without discoloration of the skin, and without undue sensibility; both are, at some stage, diminished by recumbency and pressure; and both receive an impulse on forced expiration. Here, however, the resemblances cease. The broad distinctions are as follows:

FEMORAL HERNIA.	PSOAS ABSCESS.
No previous history of lumbar pains or impaired health.	Obscure pain in the back and the loins, and a gradual failing of the strength and vigor of the body.
When reduced, the swelling recedes with a sudden slip, and often with a gurgling noise.	Disappears slowly and noiselessly.
Without fluctuation.	With fluctuation.
Internal to the femoral vessels.	External to the femoral vessels.

The last distinction is the most important, as a psoas abscess following the sheath of the psoas muscle will be conducted beneath the outer part of the crural arch,—that part occupied by the psoas and iliacus internus,—and of course external to the femoral artery and vein, whilst a femoral hernia, following the course of the vessels, will pass through the inner part of the arch to the thigh internal to the femoral vein and artery. Should a pelvic abscess pass through the obturator foramen, or through the femoral canal, the task of distinguishing the disease from hernia would be more difficult; but a careful inquiry into the previous history of the patient, and the use of the exploring needle, will satisfactorily declare the nature of the tumor.

From *varix of the saphena magna*, femoral hernia may be distinguished by attention to a few contrasted points:

FEMORAL HERNIA.	VARIX OF THE SAPHENA MAGNA.
Marked impulse on forced expiration.	Slight impulse on forced expiration.
Not removed by pressing the tumor downwards.	Temporarily disappears by pressing the swelling downwards.
Not affected by pressing on the saphenous vein below.	Temporarily diminished by pressing on the vein below.
No varicose condition of the vein below the tumor.	Varicose state of the vein below the tumor.
When restored by the recumbent position, will not reappear when the patient rises to his feet if the saphenous opening be blocked by the finger.	After subsiding under similar circumstances, cannot be prevented from returning by pressure over the saphenous opening.

Fatty growths are frequently seen in the femoral region of the thigh, and occasionally occupy the saphenous opening. The differential peculiarities may be arranged as follows:

FEMORAL HERNIA.	ADIPOSE TUMOR.
Elastic in its consistence.	Doughy in its consistence.
Having a regular or uniform surface.	Often made up of lobules.
Impulse on coughing or straining.	No impulse on coughing or on straining.
Always reducible at some period of its history, and when restored to the abdomen does not return except in the standing position, or upon some forcible effort at straining or coughing.	Never reducible, or if so, admits only of being pushed into the saphenous opening, reappearing immediately after the removal of pressure, without reference to position, etc.

Sarcomatous and other malignant tumors occupying, as they frequently do, the front of the groin, have been sometimes mistaken for hernial tumors. Their rapid growth, irregular surface, peculiar configuration of the surface-veins, and, after a time, the purple discoloration of the overlying skin, together with their irreducibility and their distance from the saphenous opening, are sufficient to establish a just distinction between such morbid growths and femoral rupture.

Treatment.—The treatment of reducible femoral hernia consists in the application of a proper truss. The pad should be smaller than that used for inguinal hernia, and decidedly more convex, in order that it may command the saphenous opening. It should be placed at nearly a right angle with the spring, so that the pressure may be exerted in the long axis of the femoral passage, just at the inner edge of the vessel and immediately below Poupart's ligament. As in inguinal hernia, the truss should encircle the pelvis, resting in the concavity which exists below the crest of the ilium. (Fig. 337.) Nothing beyond the retention of the hernia can be expected from any apparatus whatever, as the femoral ring, lying as it does beneath Poupart's ligament, cannot be subjected to a compression sufficient to effect its occlusion.

Fig. 337.

Truss for femoral hernia applied.

In irreducible femoral hernia the concave pad should be worn, in order to prevent an increased protrusion. In the event of an accident happening to a truss, rendering it inadequate to retain the rupture, a conical compress, placed over the saphenous opening and secured by a spica of the groin, can be extemporized with advantage.

Strangulated femoral hernia.—In no form of strangulated hernia is time so important as in the one under consideration. The constriction to which the intestine is subjected by the dense aponeurotic membranes which bound the femoral rings and canal, increased by the sharp angle which the sac is compelled to make as it emerges through the saphenous opening, is sufficient, in many instances, to destroy the life of the hernial contents in a few hours. I always approach a case of femoral hernia, which has been strangled for more than thirty hours, with great distrust as to the result, and especially so when the tumor is of recent origin.

In attempting reduction, the patient should be placed under an anæsthetic, the head and shoulders well raised, the leg on the affected side flexed upon the thigh, and the latter bent upon the pelvis, with the knee turned inwards towards the opposite side. This position insures the most complete relaxation of the structures about the saphenous opening. The surgeon now draws the tumor down upon the thigh,—should it have turned up over Poupart's ligament,—and then, after using steady, gentle compression to its sides for one or two minutes, pushes it backwards into the external femoral opening, and at the same time upwards in the direction of the internal femoral ring. The reduction will be favored by placing the thumb and fingers of the other hand on the margin of the saphenous opening, in order to prevent the contents of the hernia from overlapping its sides. To secure the full benefit of taxis, it

is absolutely necessary that the practitioner should understand the anatomical peculiarities of the femoral region. The three movements demanded for reduction, by the relation of the hernia to the region through which it descends, are the following,—*downwards*, *backwards*, and *upwards*. If these have been properly tested for six or eight minutes without success, an immediate resort to the knife will be necessary.

Operation.—The patient should be brought close to the edge of the bed, or he may be laid across the bed, with the limbs resting on a chair or a stool placed at its side. A vertical incision is next made over the entire length of the tumor, beginning a little above Poupart's ligament. The layers requiring dissection are the skin, superficial fascia, and cribriform fascia. These should be raised and incised with great care upon a grooved director, displacing with the point of the instrument any glands or masses of fat which may be in the way of the dissection. Occasionally the superficial pubic vessels will require a ligature, though the bleeding is usually very slight in this operation. After exposing the sac, the surgeon must seek for the stricture, which is generally found to consist of the upper horn of the falciform process of the sartorial part of the fascia lata, commonly called Hey's ligament, or at Poupart's ligament. I have never met with a case in which the constriction was at Gimbernat's ligament. The sac should now be pressed down with the fingers of one hand, while the probe-point of the hernia bistoury is slid flatwise under the overarching fascia above, and its edge turned against the tense membrane with sufficient firmness to produce a slight division of its structure, after which the parts can be stretched to the required extent if the first nick is not sufficient. An attempt should now be made to effect reduction without opening the sac; failing in this, the sac must be divided and its contents exposed. This accomplished, the surgeon will introduce the index finger into the neck of the sac, and, finding the stricture to be there, proceed to relieve it in the same cautious way as when at Hey's or Poupart's ligament. In using the knife for the purpose, the position of the blood-vessels must be kept in mind. The position of the femoral vein, to the outside of the hernia, renders an incision in that direction dangerous. The division should always be made directly upwards. The artery most exposed to injury is the obturator, which is derived from the epigastric and passes over the neck of the sac to the thyroid foramen. As this anomaly is a very common one, the operator should always act as though it were present, and, to avoid wounding the vessels, should blunt the edge of the knife by drawing it over his forceps. The instrument will thus be rendered too dull to harm the artery, and yet will be sufficiently sharp to divide a tense membrane like the stricture. The hernia having been returned into the body, the parts should be tacked together with a few stitches of the interrupted suture, and a compress applied, to be maintained lightly in place with two strips of adhesive plaster. The objection to the spica roller is that it prevents the escape of discharges from the wound.

Umbilical Hernia.

Two varieties of hernia appear in the median line of the body,—the *umbilical* and the *median ventral*. Umbilical hernia may be both *congenital* and *acquired*.

The congenital form of hernia is often associated with other defects in development, and is caused by an imperfection in the umbilical cicatrix and in the recti muscles allowing a portion of the abdominal contents to pass through the orifice, and by separating the umbilical artery and veins to form for itself a cavity in the connecting cellular and gelatinous tissue of the cord. The absence of the skin, and the translucent nature of the uniting substance of the umbilical cord, will admit of the hernial contents being seen within its substance. So delicate is this covering which incloses the intestine that it has been known to give way and leave the bowel uncovered.

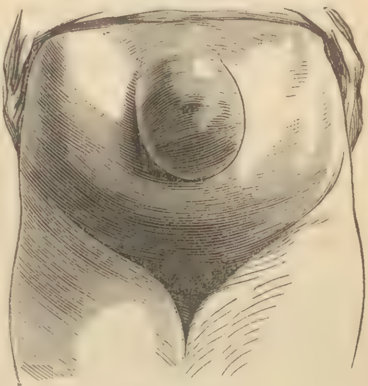
Acquired umbilical hernia is met with both in infants and in adults.

The infantile form of the disease may immediately follow birth, even before the fœtus is separated from its placental connection,—a fact which suggests the propriety, on the part of the accoucheur, of always examining the umbilical end of the cord, in order to ascertain if such a hernia exists, since otherwise the intestine might be included in the ligature which surrounds the funis. Usually, however, infantile umbilical rupture appears in four or five months after birth, or before the constituents of the umbilicus have become firmly cicatrized to the surrounding structures.

The disease is usually caused by crying or by straining, and hence its frequency in children who suffer from colic or intestinal tenesmus.

Umbilical hernia of adults.—Women are very much oftener the subject of the disease than men; and the obese suffer oftener than the spare. Females who have borne children are most disposed to this rupture. In every hundred cases of hernia, five or six will prove to be of the variety under consideration. The size to which umbilical herniæ grow, especially on very fat persons, is remarkable. The sac contains omentum, a portion of the large and small intestine, and occasionally the stomach, spleen, and liver. Gay and Nourse each found the latter in an umbilical hernia, and Professor Gross records a case in which the sac contained the gravid uterus at nearly full term. The weight of the tumor when large drags the umbilicus down very much below its usual situation. (Fig. 338.) Considerable discrepancy of opinion has existed in reference to the coverings of an umbilical hernia. De la Faye, and, later, Petit, denied the existence of a hernial sac, alleging that the peritoneum was always torn. This accident, no doubt, does sometimes occur, but it is by no means common. On the contrary, the presence of a peritoneal covering has not only been demonstrated by Cooper and by Scarpa, but has also been amply confirmed by many later writers. In addition to a sac, the hernia is covered by cellular tissue and the skin. In large herniæ the superincumbent parts sometimes become greatly attenuated, the peritoneum and fascia disappearing by absorption, in which case the contents of the tumor are almost directly in contact with the skin; a fact of some importance, and inculcating caution when it becomes necessary to operate in cases of strangulation. This thinning of the tissues may eventuate in ulceration and sloughing. Such was the result in an Irishwoman who was at one time under my care. When the slough dropped off, a portion of omentum slipped through the opening, and, becoming constricted, caused symptoms of strangulation, for which I was obliged to operate.

Fig. 338.



Umbilical hernia.

Symptoms.—The signs of an umbilical hernia are generally very distinct, and consist of a convex, irregular, or pyriform swelling, protruding at the navel, varying in size from that of a marble to that of the adult head, increased on coughing or by an energetic expiration, yielding both a resonant and a flat sound on percussion, and in its early stage receding during recumbency, or susceptible of being reduced by pressure. It is frequently accompanied with colicky pains, flatulency, and nausea.

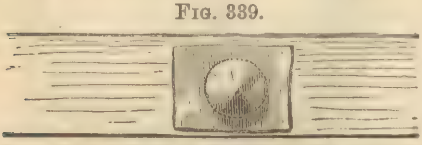
Diagnosis.—Umbilical hernia is not likely to be confounded with any other affection, though the presence of a fatty or a malignant tumor, when situated in this region, might embarrass one not conversant with such diseases. The fatty tumor is generally lobular; yields a uniformly flat percussion; communicates no impulse; is not affected in size by coughing or straining; nor is it reducible. In malignant disease the induration is unlike the mixed elastic

and doughy feel of a hernia. In addition, the immobility and irreducibility of such a tumor, and the absence of any increased protrusion during acts of forcible expiration, are quite sufficient to distinguish it from rupture.

TREATMENT.—For cases of congenital umbilical hernia there are two plans of treatment,—by compression and by ligature. The first is to be preferred, being less likely to induce peritonitis. The hernia must be pressed from the cord into the abdomen, and while an assistant retains the sides of the aperture in close contact a conical compress is laid over the navel and retained in place by a broad strip of adhesive plaster extending around the body of the child. When the ligature is used, two or more pins are passed through the sides of the abdominal opening,—care being taken not to wound the peritoneum,—and the parts are drawn together by threads, after the manner of the figure-of-eight suture.

In infantile hernia, a truss should be applied immediately on the appearance of the disease, with the almost certain prospect of effecting a cure. I have long been in the habit of using a very simple contrivance, and one which demands scarcely any skill to construct. A cork about one inch in diameter is cut into a plano-convex form, three-quarters of an inch thick from the base to the summit; its flat surface is then placed upon the centre of a strip of porous plaster three inches wide and sufficiently long to encompass the body of the patient. I prefer this plaster to the ordinary adhesive material. The exposed part of the cork should next be covered by a piece of soft chamois leather, which can be stitched in a circular manner to the plaster. (Fig. 339.) In the application of this dressing the pad or cork should be placed directly over the navel, and the two ends of the plaster carried round the body during the act of expiration, by which it will be fixed with sufficient tightness to insure the necessary pressure. Such a dressing will maintain its place securely for four or five months, when it can be renewed. This simple contrivance I have found to prove more satisfactory than the umbilical truss so commonly applied in cases of infantile rupture. A very common defect in the pad of the ordinary instrument is its long nipple-shaped process, which by acting as a wedge is calculated to prevent closure of the umbilical aperture; and when this truss is used, care should be taken that a convex block be substituted for the conical one.

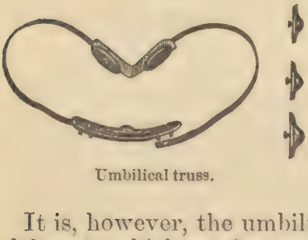
FIG. 339.



Form of the cork-pad bandage for infantile umbilical hernia.

In the management of umbilical hernia in the adult, a truss should be early applied, as there is always a strong tendency in the rupture to increase in size and to become irreducible from adhesion of its contents either to the sac or to each other. There are two trusses which answer well as means of retention in ordinary cases. One consists of a convex pad two inches or two inches and a half square, having elastic bands attached to surround the body; the other is a large concave pad, with a convex prominence in its centre (Fig. 340), which is placed over the umbilicus and retained in place by two steel springs surrounding the body. (Fig. 341.)

FIG. 340.

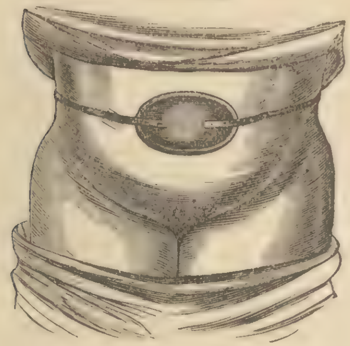


Umbilical truss.

It is, however, the umbilical herniæ of very obese women, with pendulous abdomen, which so often perplex the surgeon. In such something more than a mechanism to control the hernial aperture is needed. There is required a general support for the entire abdomen. A few years ago I had Mr. Seeley, of this city, prepare an apparatus which has given me great satisfaction in cases of both reducible and irreducible umbilical rupture. For the first, or reducible form, an oblong hard-rubber convex pad, three inches long by two

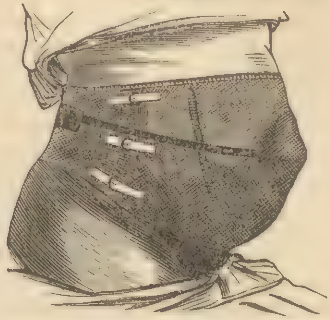
and a half inches wide, and having two studs, one at each end, is fastened to an elastic bandage shaped so as to be adapted to the form of the abdomen and capable of being tightened by straps and by buckles placed at each side, designed to unite the front with the back part of the bandage. Two steel springs covered with hard rubber, having a slot at one end and a pad at the other, with a connecting strip of leather, complete the apparatus. To apply

Fig. 341.



Umbilical truss applied to the body.

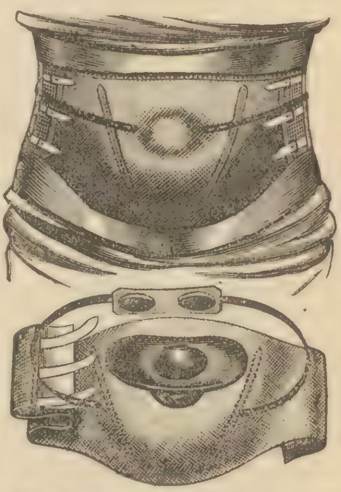
Fig. 342.



Side-view of the apparatus applied for reducible umbilical hernia.

this truss, the hernia should be pushed back and the pad be laid over the seat of the protrusion; next the elastic bandage must be drawn up, by means of the side-straps and buckles, sufficiently far to give the requisite support, after which the steel springs are placed around the body, the pads resting on each side of the spine posteriorly, and the slots slipped over the two studs on the anterior convex block. (Fig. 342.) In cases of irreducible hernia, where the object is to prevent the increase of the tumor, it is only necessary to substitute a hollow pad for the convex one. (Fig. 343.) In all other respects the apparatus is the same as that described for reducible forms of the disease. In place of the hard-rubber concave pad, I direct one to be formed out of gum-wood, which can be readily prepared of any size by a turner.

Fig. 343.



Below, concave pad for irreducible umbilical hernia, with belt and with spring detached, and above, the same applied to the body.

Persons suffering from large irreducible umbilical hernia are frequently harassed with symptoms which simulate those of strangulation, such as abdominal pains, flatulency, tenderness over the rupture, constipation, and frequently vomiting. These phenomena are generally the consequence of some imprudence in diet, the intestine becoming distended with gas, or perhaps from its coils becoming entangled with the omentum. In such cases evacuations from the bowels should be solicited by large injections of warm water containing salt, or of flaxseed-tea and turpentine. The abdomen should be covered with hot fomentations, and small doses of calomel and opium (one-sixth grain of calomel and one-fourth grain of opium) administered every hour until relief is obtained. Persons having such herniæ should be counseled to exercise the greatest care in regard to articles of food. Everything calculated to produce flatulency must be discarded, and daily alvine evacuations secured.

Strangulated Umbilical Hernia.—Of one hundred cases of strangulated hernia, about six or seven will be of the umbilical variety. The symptoms of strangulation are often of a slow or chronic character, rather, indeed, those of obstruction than of strangulation. These are nausea, vomiting, and severe colicky pains in the rupture, the latter becoming very intense, either generally or at some particular part, together with constipation. These symptoms may continue for two or three days, and yet the patient be conducted safely through the attack without a resort to the knife. In most cases of umbilical hernia a considerable amount of omentum is present in the sac with the bowel. The former, lying as it does as a broad membrane immediately between the intestines and the umbilicus, is liable to be protruded through the orifice of the navel, or through an opening in the linea alba, in such a manner as to invest the peripheral surface of the intestine like one of the coverings, rather than to be projected as a fold, the form in which it generally appears in other varieties of hernia. The pseudo-strangulation may be produced by an error of diet, the bowels becoming filled with gas, or, if the rupture be an irreducible one, by an additional coil of intestine entering the sac, or by some entanglement of the contents. Whatever the cause, not a moment is to be lost in overcoming the difficulty. The patient should be placed under the influence of an anæsthetic, the head and the shoulders raised, and the limbs drawn up so as to relax the abdominal parietes. The surgeon next grasps the tumor with one or both hands, according to its bulk, and, after drawing it forward in order to elongate and consequently narrow its contents, he compresses it with a view to displace the flatus, and, lastly, pushes the contents of the rupture upwards and backwards. If a certain portion of the hernia be more tense and resistant than the rest, the taxis should be addressed to that part, as it is highly probable that the obstruction is dependent upon the presence of a loop of intestine in addition to that ordinarily within the sac. Should the taxis fail, calomel and opium offer a good prospect of success. One-fourth of a grain of each, given every hour until twelve or fourteen consecutive doses have been taken, accompanied by the application of ice in a rubber bag or in a bullock's bladder to the tumor, will frequently result in the subsidence of all the symptoms, or will enable the surgeon, when, after twelve hours, he renews the taxis, to accomplish with ease the reduction of a part or the whole of the hernia. In two instances, in the case of a lady whose umbilical hernia had become strangulated and where taxis had failed, I was able to restore the rupture by renewing the manipulation fourteen hours later, calomel and opium having been administered and cold applied locally during the interval. Great benefit is occasionally derived in these cases from administering, after the first five or six hours of the above treatment, a large enema of flaxseed-tea and turpentine. The stimulus of the injection appears to excite a peristalsis, which is imparted to the implicated intestine, if the latter be not too tightly constricted, and favors the expulsion of the contained gas. When the symptoms become more acute, as will be manifested by obstinate vomiting, often stercoraceous, by increase of pain, and by febrile disturbance, the only hope for the patient is in an operation.

Operation.—An incision should be made exactly in the mesial line, commencing two inches above the upper part of the tumor and terminating some two or three inches below, upon the surface. As the coverings are often greatly attenuated, the knife must be used with caution. The different layers, consisting of the integument and the subcutaneous adipose tissue, being raised and divided on the director, the linea alba and then the sac will be exposed. Clearing away with the director any bands of connective tissue which may still remain adherent, the finger should search for the tendinous margin of the umbilical opening, where perhaps the constriction will be found, and, if so, it may be relieved by passing between the tendon and the sac the usual herniotomy bistoury and cutting in a direction away from the hernia. It will be fortunate if the reduction can be effected without dividing the sac,

for when the latter becomes necessary the doom of the patient is probably sealed, death following in almost all such cases. If, however, the strangulation cannot be overcome without such a resort, there is no alternative but to lay it open and divide the stricture within. If the contents are found extensively adherent, no further attempts at reposition should be made; the constriction being relieved, the intestine or omentum may be allowed to remain in the unreduced state. Before deciding upon this course, however, the surgeon should carefully unravel the one from the other, to determine their irreducibility. If the intestine has become gangrenous, it is to be treated in the same manner as in other forms of rupture under similar conditions. Holmes* records a case of strangulation which was referred to an umbilical hernia, but which afterwards was found to be within the abdomen, and suggests that where, under a like misapprehension, the umbilical sac is opened and no explanation for the strangulation is found, the finger should be carried into the abdomen in search of the constriction, as was once done successfully by Mr. Bryant. Anomalous cases are occasionally met with in which the hernia is bilobed and the constriction is caused by the separating band; and in still rarer instances the rupture, though forming a single swelling, has passed through two distinct openings in the median line contiguous to each other. After the operation is completed, and if the contents are in a sound condition, the parts should be brought together by the interrupted suture, and supported by a light compress and a broad bandage, or by a strip of adhesive plaster.

Ventral Hernia.

Ventral hernia may appear at any part of the abdominal walls. The usual situation of such, however, is in the course of the linea alba, and, for anatomical reasons, oftener above than below the umbilicus, the recti muscles diverging from each other as they ascend to their thoracic attachment, and leaving the "white line" less protected in this region. In the lumbar region there is a small space posterior to the angle formed by the intersection of the external and internal oblique muscles, which occasionally admits of a protrusion, forming a *lumbar hernia*.

The Germans describe a form of ventral hernia not entitled to that distinction, as it consists of an extreme extension or stretching of the entire anterior abdominal walls.

Causes.—Generally this form of rupture is the result of wounds weakening the parietes, or of the stretching of the tissues incident to the parturient state. I have seen such herniæ form after Cæsarean section, and in one case of the kind was obliged to operate for a strangulation of the mass. A lady was recently under my care in whom, judging from the size of the swelling, all the intestines were external to the abdomen, having passed through the linea alba, forming a pendulous tumor, which lay between the thighs. The contents of this protrusion could be returned, and the edges of the recti muscles distinctly felt by the fingers.

Contents.—The contents of a ventral hernia do not differ in any particular from those of other varieties of the disease, except when small, when it is said that the omentum alone is the usual occupant of the sac. Hoin and Garengeot speak of one form of the affection in which the stomach alone constitutes the tumor, an inference drawn from the gastric irritability which is present. Scarpa, however, could discover no reason why, in such a case, other portions of the intestinal tube may not be included, and states that no dissection has ever been made to prove the contrary. The irritability of the stomach he considers to be merely sympathetic. The locality of the protrusion, on the left side of the ensiform cartilage, constitutes the only difference from hernia in the median line.

The coverings of a ventral hernia are the skin, the subcutaneous cellulo-

* Surgery, p. 650.

adipose tissue, and the peritoneum; when the rupture occurs in the lumbar region, some of the fibres of the transversalis muscle may be added.

Ventral hernia, when in the linea alba, can be distinguished from the umbilical form of the disease by the following peculiarities. Ventral hernia becomes a pedunculated swelling when it attains to any great size; umbilical hernia retains its spherical or round figure without regard to bulk. Ventral hernia, passing through a slit-like opening in the linea alba, possesses a neck which is somewhat oblong or flattened, whereas umbilical rupture, passing through the umbilical ring, is round in shape, and the edge of the circular aperture can be distinctly felt by the finger. Umbilical herniæ increase in volume much more rapidly than do the ventral, and cause a marked change in the appearance of the navel. As in umbilical rupture, so in ventral, the patient is often annoyed by gastric and intestinal irritation, giving rise to flatulent colic, constipation, and sometimes nausea.

Treatment.—Reduction is best accomplished by placing the person in the recumbent posture, relaxing the parts by position, and applying pressure or taxis to the swelling. Should it not recede spontaneously when restored to the abdomen, a truss similar to that used for umbilical rupture will be necessary to the patient's safety. If the protrusion be situated at some other point than the median line, the instrument will have to be modified to answer the peculiarities of the case.

Obturator Hernia.—Obturator or thyroid hernia passes from the interior to the exterior of the pelvis through an opening in the upper part of the thyroid membrane, occupied by the obturator artery, vein, and nerve. The position of the hernia is such that it is clearly recognizable only when the tumor is of considerable size. The sac is formed by the peritoneum, and its contents may be either intestine or omentum. The coverings consist of the skin, subcutaneous cellular tissue, fascia lata, pectineus, and adductor longus muscles. The relation of the obturator vessels and nerves to the neck of the sac is not always uniform. In the fifteen cases collected by M. Vinson, the vessels were situated in six cases on the inside, in six on the outside, and in the remaining three behind the sac.*

Symptoms.—Obturator hernia would scarcely be suspected unless the attention of the surgeon were called to its possible existence by the symptoms of intestinal or omental strangulation being present, without there being any rupture in the ordinary hernial localities. When such signs exist, and are found associated with an appreciable fullness and hardness in Scarpa's triangle, with the femoral artery pulsating in front, the femoral and inguinal rings being free, and perhaps some pain experienced along the inside of the thigh, answering to the distribution of the obturator nerve, the existence of an obturator hernia may be inferred. As other forms of hernia may coexist with the thyroid, a careful diagnosis in a case of strangulation of the latter could be reached only by finding the former reducible. This form of rupture rarely occurs in persons under forty-five or fifty years of age. It is supposed that the wasting of the muscles about this time of life has something to do in its production. Operations have been frequently performed to relieve the strangulation of obturator hernia. M. Obré† was able to diagnose a case of this kind in consequence of discovering, on a comparison of the two thighs of a patient suffering from signs of intestinal strangulation, a little more fullness of the Scarpa space on one side than on the other. Guided by these appearances, he operated with success. Mr. Bransby Cooper‡ also operated successfully on a case of obturator hernia at Guy's Hospital. In this instance the fibres of the pectineus muscle appeared to have caused the stricture, as after their division the hernia underwent spontaneous reduction. Mr. Birkett has collected twenty-five cases of strangulated thyroid hernia,

* Nélaton's "Élémens de Pathologie Chirurgicale," vol. iv. p. 403.
† Medico-Chirurgical Transactions, vol. xxxiv. p. 232.
‡ Medical Times, vol. i. p. 113, 1853.

and others are occasionally noticed in medical journals: so that the disease cannot be regarded as extremely infrequent.

TREATMENT.—When reducible, the rupture should be returned by elevating the pelvis, flexing the limb upon the abdomen, and making firm pressure downwards and upwards. To prevent a recurrence of the protrusion, a truss must be worn with a conical pad so adjusted as to press backwards and upwards. Holmes states that Mr. Kingdon has in five instances reduced thyroid hernia.

When there is reason to infer the existence of a strangulated obturator hernia, an incision three inches in length should be made in front of the thigh, over the saphenous opening, extending from Poupart's ligament downwards, dividing in succession the skin, the superficial fascia, and the fascia lata femoris. The pectineus and the adductor muscles, being now exposed, should be raised and severed sufficiently to expose the sac, when the reduction may be effected by nicking the seat of stricture, which, as nearly as can be ascertained from the cases collected, and from the anatomical peculiarities of the region, will be found in the edge of the thyroid membrane, at the neck of the sac, or in the fibres of the pectineus muscles.

Ischiatic Hernia.—In this form of rupture the hernia passes through the great sacro-ischiatic foramen in the course of the sciatic blood-vessels, below the pyriformis muscle, and is concealed by the gluteus maximus. Such cases are exceedingly rare, and perhaps would never be recognized. Sir Astley Cooper records a fatal case of strangulated ischiatic hernia which was discovered only after death. The dissection in this instance showed the existence of a sac, the mouth of which lay in front of the internal iliac artery and between the obturator artery and veins,—the former being above and the latter below. The application of a truss in the event of such a rupture being diagnosed would be of doubtful utility, as the pressure of a pad could not be made so as to command the outlet with any degree of certainty. Should a gluteal hernia occur, it would differ from the ischiatic variety only in escaping from the pelvis above the pyriformis muscle.

Diaphragmatic Hernia.—There are three ways in which the abdominal viscera may enter the chest, constituting this form of hernia: first, from a congenital imperfection in a portion of the diaphragm, usually on the left side; second, by a dilatation of some one of the natural apertures through which pass the œsophagus, aorta, and ascending cava; and, third, by a wound of the muscle. When from the last-named cause, such herniæ are usually fatal; though I have given a case, under the head of abdominal wounds, in which a person lived many years after an accident of this kind. There are no means of determining with certainty this form of hernia; though the intestinal disturbance, and the existence of tympanitic and gurgling sounds within the thoracic walls, together with the presence of great thirst, would serve to render probable the existence of this affection. Even if it were recognized, the surgeon would be powerless to relieve his patient without an operation, which would, in all probability, prove as fatal as the disease itself.

Pudendal Hernia is occasionally seen forming a tumor in the labium, which it reaches by passing down between the vagina and the ramus of the ischium. It can be recognized by the impulse communicated on coughing, by its soft, elastic feel, and by its reducibility on pressure applied close to the inner edge of the ramus of the ischium. I have never been able by any contrivance to prevent the return of the hernia after reduction. An oblong compress applied over the labium and retained by a T bandage, or an ivory pad attached to the truss, sometimes worn for prolapsus ani or for hemorrhoids, may be employed; but either will be found unsatisfactory, and will soon be laid aside. I have never seen any disability arise from the presence of such a rupture; but my experience in this variety of hernia is quite limited.

Vaginal Hernia.—In this rupture the tumor does not descend so low as in the pudendal variety. It is situated within the orifice of the vagina, encroaching upon this canal, and is a soft, compressible tumor, having an impulse on coughing, and easy of reduction, though quickly reappearing on the removal of pressure. The course of this hernia corresponds to the space between the rectum and the uterus, and, when it does not arise from a congenital imperfection of the parts, is doubtless most commonly caused by the overstretching of the vaginal walls and the underlying connective tissue, in parturition. A protrusion of the bladder frequently occurs in the female, which must not be confounded with vaginal hernia. The distention of the former by the accumulation of urine, and its collapse after the passage of that secretion, together with the fact that the catheter can be carried into the swelling through the urethra, will serve to establish the distinction.

Perineal Hernia appears in the perineum, a little to one side of the raphé, forming a noticeable swelling, of a round shape, between the bladder and the rectum in the male, and between the rectum and the vagina in the female. The route followed by this form of rupture before reaching the perineum is along the inner surface of the levator ani muscle. It is this muscle which prevents the protrusion from passing into the ischio-rectal space and appearing at the side instead of in front of the bowel. How the rupture is related to the pelvic fascia has not been determined. If the latter were torn, the hernia would lie between the recto-vesical and the levator ani layers of the fascia; and if not broken, it would seem necessary that both the lamina of this membrane which is reflected on the side of the bladder, and that between the bladder and rectum, should form coverings. The swelling does not always appear in the perineum, but can be discovered by an examination through the rectum. The disease has followed the operation of lithotomy, in consequence of a careless division of the peritoneum with the gorget.* In the parturient female, the danger from pressure by the child's head would prove very serious in the event of such a hernia being present. The same would be true of the vaginal form of the disease. The existence of this hernia can be inferred from the presence of intestinal disturbance, from the sound emitted when it is pushed back, and from its impulse.

TREATMENT.—The use of a large pessary has been recommended as a means of preventing a descent of the rupture, as has also the application of a hemorrhoidal truss the pad of which shall be so formed as to rest firmly against the perineum. The first appliance fulfills the indication very imperfectly, and the second cannot do more than prevent a further increase in the protrusion.

Sacro-Rectal Hernia.—It has happened that in a case where the pieces composing the sacrum have failed to join by ossification, a portion of the intestine has passed through the defective part and formed a tumor over the lower part of the spine, to which the above name has been given. Such a swelling would bear some resemblance to spina bifida, but could be distinguished from the latter by its reducibility, by the gurgling sound heard on its restoration into the pelvis, and by its expansive impulse. The treatment of such a hernia would consist in securing a pad over the seat of the protrusion by either a porous or an adhesive plaster, or by a spring truss, until the opening became closed by progressive ossification.

Cystocele.—In addition to the forms of rupture already described, the bladder has been known to protrude through the external abdominal ring, and also through the femoral opening; and in one case of inguinal cystocele given by Ruysch, the sac contained a portion of intestine in addition to the bladder. Verdier, Petit, and Pott have each given an instance of cystocele in which the bladder contained calculi. These formations no doubt were

* Cooper's Surgical Dictionary, vol. i. p. 998.

caused by the obstruction offered to the escape of the urine in the unnatural positions of the viscus. A curious case is related by Verdier, in which the stone in a cystocele was mistaken for a bubo, and caustic applied for its destruction, by which a urinary fistula was formed.*

The cause of vesical hernia is probably habitual neglect in passing the urine, in consequence of which the walls of the organ become overdistended and the ligaments unduly stretched, thus allowing the organ to be pressed into unusual channels by the superincumbent viscera.

Symptoms.—The presence of fluctuation, the desire to urinate on compressing the tumor, and the diminution of the latter during micturition, will enable the practitioner to recognize the nature of the affection.

Treatment.—After reducing the cystocele, a truss should be applied to prevent its return.

The *diverticular hernia* of Littré consists of either a congenital offshoot or a prolongation from some portion of the intestinal canal, generally the ileum. Or it may be formed by a protrusion of the serous and mucous coats of the bowel, in consequence of the muscular tunic giving way. In either condition the affected portion of the tube may enter the inguinal or the femoral canal and constitute the contents of the sac.

* Cooper's Surgical Dictionary, vol. i. p. 100.

CHAPTER VII.

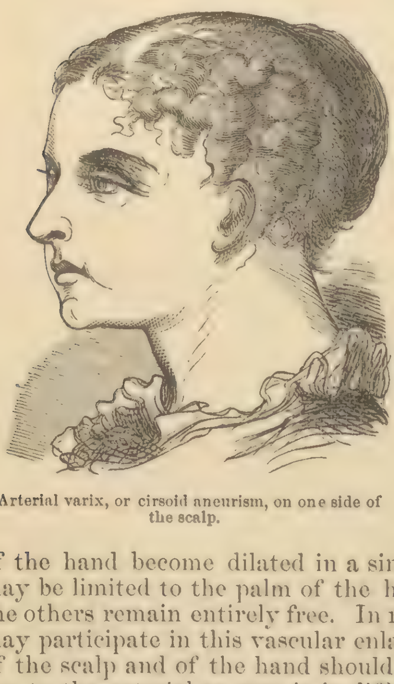
DISEASES AND INJURIES OF THE BLOOD-VESSELS.

Angeiomata.

The term angeiomata is applied to a class of tumors which consist for the most part of blood-vessels. They include in their anatomy, arteries, capillaries, veins, and connective tissue. These growths are often congenital, though occasionally they arise from external violence. There are three varieties of angeiomata,—the *arterial*, the *capillary*, and the *venous*. The arterial varix is sometimes called *cirsoid aneurism;* the capillary varix is frequently described as *aneurism by anastomosis.*

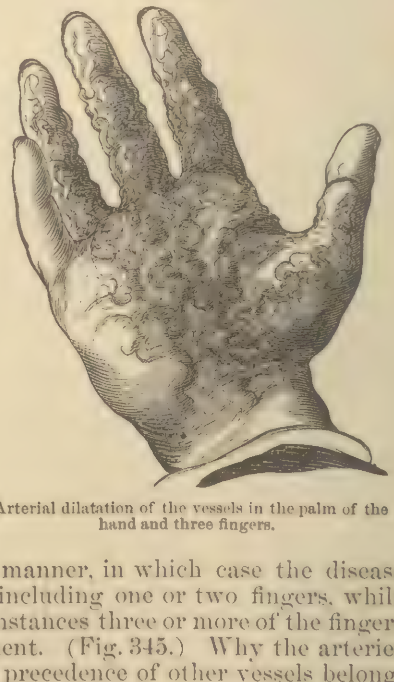
Arterial Varix.—This is a dilatation of one or more arterial branches. As the vessels dilate they become lengthened and exceedingly tortuous and convoluted in their course. Sometimes they turn completely upon themselves, forming a spiral cord. This condition of the arteries is the counterpart of venous varix. The convolutions are united together by means of a small amount of connective tissue. The arteries chiefly affected are those of the scalp. In Fig. 344 there is a very good illustration of extensive cirsoid disease of the temporal and occipital arteries on one side of the head, taken from a young woman who applied at my clinic for relief. Occasionally the vessels

Fig. 344.



Arterial varix, or cirsoid aneurism, on one side of the scalp.

Fig. 345.



Arterial dilatation of the vessels in the palm of the hand and three fingers.

of the hand become dilated in a similar manner, in which case the disease may be limited to the palm of the hand, including one or two fingers, while the others remain entirely free. In rare instances three or more of the fingers may participate in this vascular enlargement. (Fig. 345.) Why the arteries of the scalp and of the hand should take precedence of other vessels belonging to the arterial system it is difficult to understand. These trunks have naturally a serpentine form, but this circumstance, while it may favor the

contorted disposition of the vascular elements of the tumor, could have no influence in determining the dilatation of its blood-vessels. As the disease frequently appears after an injury to the vessels, it is highly probable that there is an inflammatory cause in operation to produce the remarkable changes which follow. There are no reasons for supposing that these can be the result of those structural alterations which often give rise to true aneurism, such as atheroma. This form of arterial dilatation differs from that of aneurism in the expansion of the vessel being more general and uniform. though in some instances distinct circumscribed pouches or sacs are pushed out from the sides of the vessel. The walls of the arteries, as the disease advances, become more and more attenuated, chiefly at the expense of the muscular and elastic coat, until the surface of the tumor presents a blue color, from the blood being seen through the integument, the latter having been thinned out by the pressure from within. When the head is allowed to hang down, causing the dilated trunks to distend, this color is very noticeable. So thin do the walls of the affected vessels become, that when divided they collapse in the same manner as does a cut vein. Though the swelling is composed chiefly of arteries, yet, in consequence of the sluggish movement in the inordinately capacious channels, the blood is more venous than arterial in its character. Quite recently I have seen two cases of cirsoid disease of the scalp—one in a man and the other in a woman—in which there was a very marked absorption of the cranial bones beneath the varix.

Symptoms.—The signs of arterial varix are quite characteristic. Such a tumor consists of a bundle of soft, compressible, tortuous, and pulsating swellings in the course of the principal vessels of the scalp, over which the skin presents usually a bluish color.

Treatment.—Except in cases where the disease shows a tendency to extend rapidly and the vessels to open, no operative measures should be attempted. I have witnessed this form of varix in persons over sixty years of age, in whom it had existed from birth, and who suffered very little inconvenience from its presence. But there may be exceptional cases—for example, when repeated hemorrhages threaten to destroy the patient's life—in which the surgeon is compelled to resort to some measure for the cure of the disease. Under such circumstances there are several plans from which he can select. Professor Bruns* has advocated the ligature of the two external carotids, the vessels which most directly, through their branches, supply the scalp with blood. Ligature of the primitive carotid on the affected side has been performed by Mussey,† Warren,‡ Bush,§ Wood,‖ and Mott in this country, and by several surgeons in Great Britain and on the Continent; but out of eighteen cases it does not appear that the operation, except in two instances, was followed by permanent benefit, and on three occasions the patient perished under the knife.¶ It has been proposed by Von Gräfe, who has performed the operation in this way, to divide the mass of dilated vessels crosswise, afterwards stuffing the wound with agaric and sponge, with the double object of arresting the hemorrhage and of inducing a destructive suppuration in the parts. Brodie attempted the removal of an arterial varix by passing a pin beneath the growth and strangulating the mass by means of a strong ligature; ultimately, however, the disease returned. Resort has been had to galvano-puncture,—introducing needles into the tumor and connecting them with the poles of a powerful battery,—the object being to induce the formation of a solid coagulum in the growth. This practice has been accompanied with some degree of success. With the same object in view, injections of the perchloride of iron have been used, a plan not unattended with danger. The only operation which seems to offer a fair prospect of success is that by excision, and this should be adopted in preference to any other method when the necessity arises for its performance. The plan consists in

* Handbuch d. Pract. Chirurg., i. 161, 1854.
† American Journal Med. Sciences, 1830.
‡ Warren, Practical Remarks on Tumors.
§ New York Medical Journal, vol. i., 1819.
‖ New York Journal of Medicine, 1857.
¶ Holmes's System of Surgery, vol. iii. p. 538.

commanding the blood-supply of the growth by cutting down at its circumference and beyond the limits of the disease and securing the vessels in detail. The operation demands great care and patience, short incisions being first made through the skin and a stout thread immediately passed, by means of a curved needle, beneath the exposed vessels. This procedure is repeated until the entire varix has been invested, when the diseased mass may be removed, after which the wound should be covered with an ordinary water-dressing. Professor Gibson* adopted this plan with success as early as 1823. It has been repeated by Mussey and others with satisfactory results.

Capillary Varix.—This is an erectile growth, sometimes designated by the term *telangiectasis*, and not unfrequently by that of *nævus maternus*, or *mother's mark*. There is no part of the body exempt from this affection, except such tissues as are non-vascular. There are two varieties of capillary varix,—the superficial and the deep. In the first the disease is limited to the superficial part of the skin, appearing as a red or claret-colored spot or stain, and varying from the size of a millet-seed to several inches in extent. The surface of small nævi is often surmounted by small, granular elevations, resembling a strawberry or a raspberry. The disease is generally congenital, but may arise after birth, not unfrequently in consequence of some local injury. Mothers often refer these marks to some mental impression received during pregnancy. In answer to the question which I once addressed to a lady whose infant had a round red nævus over the eyebrow, "To what circumstance do you attribute this mark on your child?" she replied, "While riding on horseback, the animal carried me under a cherry-tree, and a ripe cherry struck me on the forehead." Another mother, whose child bore on his shoulder the mark of a horseshoe, ascribed the disease to her horse falling and striking her on the back with his foot.

The deep variety occupies the lower layers of the skin, presents a blue color, can be emptied of its blood by pressure, and when large possesses a pulsation synchronous with that of the heart. Under excitement the growth deepens in color and becomes turgid with blood. The most common localities for the development of nævus are the scalp, face, ear, breast, back, genitalia in the female, and bones. (Fig. 346.) In some instances they are found scattered over almost the entire surface of the body. On the scalp they frequently elect the integument over the anterior fontanelle as a point for development. Their progress varies greatly in different persons. Frequently they remain stationary to the latest period of life. Sometimes they grow rapidly for a short time and then cease, and in a few instances they disappear spontaneously, or, receiving an injury, are destroyed by inflammatory changes which follow. Though a source of great anxiety to parents, and not unfrequently of mortification to children, yet, even in the most aggravated examples of the disease, and when left without any surgical interference whatever, they rarely if ever endanger life.

Fig. 346.

A nævus occupying a cranial bone.

Anatomy.—Nævus consists not only of intricate and anastomotic convolutions of dilated capillaries, but also of a new formation of minute vessels, supported in a frame-work of connective tissue. These vessels, though, on

* Gibson's Surgery, vol. ii. p. 340.

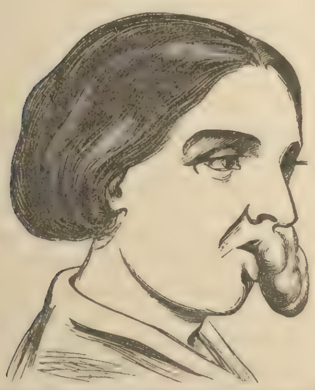
a casual inspection, appearing to be intertwined in an indiscriminate and disorderly manner, on a closer scrutiny will be seen, when injected, to be arranged into small, distinct masses, the vessels of which form a net-work that resembles in its outline the figure of the sudoriferous and sebaceous glands, to which in part they belong. (Fig. 347.)

FIG. 347.

Intricate convolution of vessels in nævi: *a*, net-work of newly-formed vessels around the site of a sweat gland; *b*, a similar net-work in the papillæ of the mucous membrane of the mouth.—From Billroth, magnified 60 diameters.

Venous Angeiomata.—These growths, almost uniformly congenital, are developed in the subcutaneous and submucous connective tissue. They are also found in some of the internal glandular organs, as the liver and the

FIG. 348.



Submucous venous angeioma of the upper lip.

FIG. 349.

Submucous venous angeioma of the lower lip.

kidneys. They are rarely seen in muscles or in bone. Occasionally they are encountered in the midst of fatty and other morbid growths. The favorite localities for these venous angeiomata are beneath the mucous membrane, on the inside of the cheek, on the inside of the upper (Fig. 348) and the lower lip (Fig. 349), over the alveolar processes of the jaws, on the tongue, and

on the palatine arches. Occasionally the disease is met with on the hand, extending over its dorsal surface and to the tips of the fingers, forming a soft, blue, spongy, and sacculated swelling. (Fig. 350.) Very recently I have seen three instances of these growths situated beneath the scalp, all congenital.

FIG. 350.

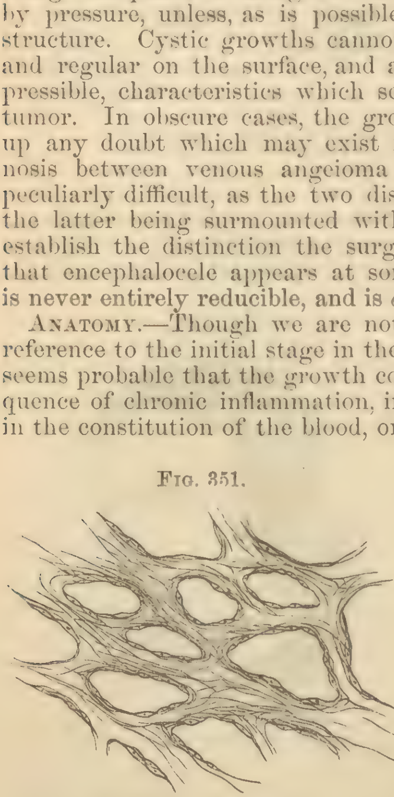
Venous angeioma of the hand.

DIAGNOSIS.—Venous angeiomata possess the following peculiarities: they have a soft, doughy, or spongy feel; they enlarge in the act of coughing or crying, or during muscular struggles; they are without pulsation. When squeezed between the thumb and the fingers they can be emptied of blood, but on removing the pressure the tumor immediately refills. Their color is leaden or blue, and it is only in exceptional cases that the tumor is congenital.

The diseases with which venous angeiomata may be confounded are lipomatous tumors, cysts, and encephalocele. Fatty growths differ from the disease under consideration in not being susceptible of changes of form or of color, and in not being diminished by pressure, unless, as is possible, a venous tumor be developed in their structure. Cystic growths cannot be emptied by compression, are smooth and regular on the surface, and are elastic instead of being soft and compressible, characteristics which serve to distinguish them from the venous tumor. In obscure cases, the grooved needle should be employed to clear up any doubt which may exist in the mind of the surgeon. The diagnosis between venous angeioma and encephalocele is in some instances peculiarly difficult, as the two diseases occasionally co-exist, the skin over the latter being surmounted with an erectile growth. In attempting to establish the distinction the surgeon will be assisted by bearing in mind that encephalocele appears at some point in the line of a cranial suture, is never entirely reducible, and is *always* congenital.

ANATOMY.—Though we are not in a position to speak with certainty in reference to the initial stage in the development of venous angeiomata, yet it seems probable that the growth consists originally of veins, which, in consequence of chronic inflammation, induced by external injury, by alterations in the constitution of the blood, or by hereditary influences, finally become transformed into a cavernous structure. The best example of this structure is the corpus spongiosum, or the corpora cavernosa of the penis. When a venous growth has been extirpated, it will be seen to consist of a reticulated frame-work of elastic connective tissue, so arranged as to present numerous compartments of various sizes and forms, which are lined with a delicate, smooth membrane, covered with the ordinary spindle-shaped cells which line the blood-vessels. (Fig. 351.) It is through these compartments or chambers that the blood circulates. At the circumference of this cavernous mass these chambers communicate with the contiguous veins. Around these growths will be found a condensation of the adjacent connective tissue, which

FIG. 351.



Section of a venous angeioma.

forms for them a capsule more or less complete. If the inflammatory origin of venous angeioma be conceded, it is not difficult to sketch the manner in which its sponge-like structure is formed. If we start with a number of small veins lying in the midst of the ordinary binding tissue, the first effect of an inflammatory hyperæmia would be to crowd emigrant leucocytes into the part, and to excite an active cell proliferation, thereby increasing the amount of young connective tissue, and tying together, with its threads, the net-work of small veins. The subsequent cicatricial contraction of the new formation would produce not only sectional constriction, but also a more forcible contact of adjoining veins than previously existed. The effect of such constriction would be to offer an obstruction to the circulation of the blood, and to cause dilatation, and finally complete disjunction, of the vessels at numerous points in their winding course; and the effect of the intensified pressure at the points where the veins lie in contact with one another would be to cause in such situations the absorption of their walls and the communication of their channels, finally establishing a number of open spaces lined by the remains of the previously existing veins, and surrounded externally by a wall of connective tissue.

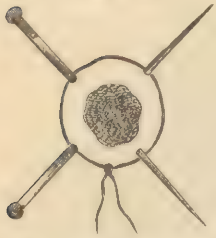
Treatment.—The great object to be attained in the treatment of either capillary or venous erectile growths is to cut off their supply of blood. This is accomplished in various ways. It may be effected by causing the coagulation of the blood in the growth, and thus offering a mechanical obstacle to its nutrition. For this purpose these tumors have been injected with the perchloride of iron, and have been treated by the galvano-cautery. The first method is not unattended with danger, death having followed the use of the injection, which is a sufficient reason for its condemnation. The second is often impracticable, from the expensive character of the apparatus necessary for its execution. Another mode of cure is by inducing a destructive inflammation in the nævus, and in this way substituting for its vascular element one of connective or cicatricial tissue. With this object in view, needles may be heated to a white heat in the flame of a blow-pipe, and passed into the substance of the tumor, or a minute particle of vaccine virus can be introduced into the nævus. Arsenious acid has been employed in the same manner. Painting the surface of the diseased spot with a strong solution of corrosive sublimate in collodium (forty grains of the first to one drachm of the last) will sometimes eradicate small patches of the disease when not deeply situated. The application of a thin layer of paste, made by mixing the crystals of chloride of zinc with a little wheat flour, will produce the same result, and with more certainty than the use of the bichloride of mercury. Solar cauterization has been effectually used for the cure of small nævi, by concentrating upon their surface, with an ordinary lens, the rays of the sun.

In cases of venous angeioma too large for excision or for strangulation, we may use, with every prospect of success, *setons*, consisting of silk threads, in number varying from three to six, and passed with a fine needle through the base of the tumor. They should be allowed to remain until a free suppuration is established in the growth, when they may be removed, first one, and after a few days a second, and so on until all are taken away. When a nævus is situated on the scalp over a fontanelle, and where, in consequence of its proximity to the membrane of the brain, it would be improper to ligate or to excise, two or three applications of fuming nitric acid, by means of a rod of glass, will be the proper remedy. With this exception, I prefer, in all cases of erectile growths, capillary or venous, to operate either by strangulation or by excision.

Strangulation.—When the nævus is small, two pins may be passed beneath the growth at right angles with each other, observing that they enter and pass out through sound skin. A strong silk or hemp thread should next be passed beneath, and drawn sufficiently tight to insure thorough strangulation. (Fig. 352.) The pins should have their points nipped off with the cutting-

pliers, and then covered with two strips of adhesive plaster. In eight or ten days the whole will drop off, leaving a new surface, which will quickly cicatrize under a simple cerate dressing.

Fig. 352.



Pins passed beneath a nævus, and ligature thrown, ready to be tightened and knotted.

Some surgeons advise the removal of the ligature five or six hours after its application, under the impression that less sloughing, and consequently less deformity, will follow the constriction. I think the advantages derived from this practice are over-estimated.

If the nævus is too large for strangulation by the two needles and a single thread, it must be treated by first pushing a pin beneath the growth in the course of its long diameter, then passing a needle bearing a strong double ligature at right angles with the pin, and, after separating the threads, tying each half separately. (Fig. 353.) If in tightening these cords they show a tendency to slip off the sound upon the diseased skin, it may be prevented by lifting the mass upwards through the pin, while the threads are drawn upon, or, if this plan fails, by directing an assistant to introduce a pin only into the skin, between the ligature and the diseased surface, retaining it in position until the threads, being tightened, form for themselves a deep groove in the sound tissues, when the pin may be withdrawn. Care should always be observed when performing the operation by strangulation to select strong hemp thread, which will admit of being drawn upon with great force. I sometimes use, with great effectiveness, a modification of the very ingenious ligature employed by the late Sir William Fergusson. A needle is armed with a long double ligature, which is passed underneath the base of the tumor in one direction and then again at right angles with the first, leaving a long, loose loop on one side and four free ends on the other side of the nævus. (Fig. 354.) Let the loop be next cut, and there will be eight distinct threads, dividing the tumor into four equal parts. The opposite threads of each quarter should now be tied together with the utmost force, the effect of which will be to cut off completely the circulation of the diseased part. To make the ligature a subcutaneous one, as was done by Fergusson, a groove must be cut in the skin over each quarter for the reception of the thread.

Fig. 353.

Tying a nævus with a pin and double ligature.

Fig. 354.

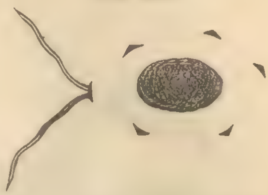
Double ligature passed under the nævus, showing the loop and four free ends.

When the growth is not large, its subcutaneous strangulation may be accomplished by inserting a needle, bearing a thread, into the sound skin on one side of the diseased part and bringing it out on the same side, a short distance from the point of entrance. Inserting it again at the point of emergence, it is pushed along under the skin and again brought out through its surface. This process of bringing the needle out and again introducing it through the same puncture is repeated until the entire growth is surrounded, when, the two ends of the ligature being forcibly drawn upon, the thread will

disappear beneath the skin and effect the necessary constriction. (Fig. 355.) When the integument is not included in the ligature, the pain consequent upon the strangulation is very greatly diminished.

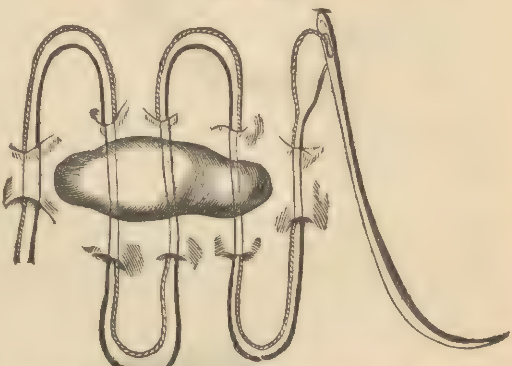
When angeiomata of extraordinary size are encountered, it will be necessary, in using the ligature, to include the diseased mass in a number of threads, after the manner practiced by Mr. Erichsen. A long double ligature, one-half being colored black, is passed beneath the tumor back and forth in such a way as to leave loose loops on both sides. (Fig. 356.) These being divided and the black and white ones of each side tied together (Fig. 357), the growth will be strangulated in small sections. When using this ligature, the ends on one side should not be tied in a hard knot, as it may become necessary to tighten the cords a second time in order to effect a thorough strangulation. The odor which is emitted in the destruction of very large nævi by the process of strangulation requires to be corrected by disinfectants. As soon as the sloughing is well established, the parts should be covered with a solution of permanganate of potash, chlorinated soda, bromo-chloralum, or, what is superior to all others, either a solution of the sulphate of iron or a fermenting poultice. In young children, the removal of a large tumor of the erectile kind by the above method will be followed by considerable exhaustion, necessitating not only an ample supply of food, but also the use of tonics and stimulants.

FIG. 355.



The subcutaneous ligature applied.

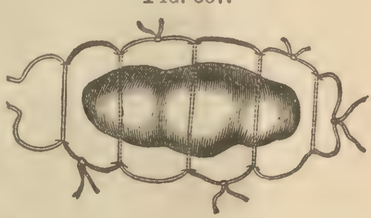
FIG. 356.



Erichsen's double ligature appled to an elongated nævus.

It will frequently happen that the ulcer left after the detachment of a large slough will be tardy in healing, in which event the sides of the raw surface must be drawn well towards each other by adhesive strips, so that by the union of the granulations the extent of exposed surface may be diminished.

FIG. 357.

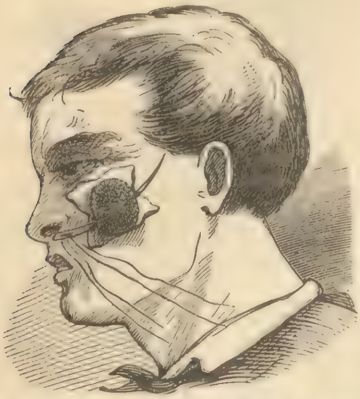


The loops divided and the section of nævus tied.

Excision.—There are several ways of practicing this plan. *First*, the diseased part may be included between two elliptical incisions and removed, the vessels tied, and the edges of the wound afterwards united by sutures or by adhesive strips. *Second*, the skin may be dissected in flaps from the growth, and the latter be strangulated by passing underneath its base a double ligature. (Fig. 358.) After its separation the flaps may be laid down over the chasm, and kept in position by sutures or by adhesive plasters. I have in this way very satisfactorily removed large venous or cavernous angeioma. *Third*, after uncovering the tumor it may be cleanly dissected away from all its attachments and at once removed, securing any vessels which show a disposition to continue bleeding, and closing the wound in the same manner as after other operations. According to Mr. Teale, the skin can be advantageously preserved even when discolored, as it subsequently assumes a natural hue. In two instances I have preserved nævoid skin when removing the disease by excision, and

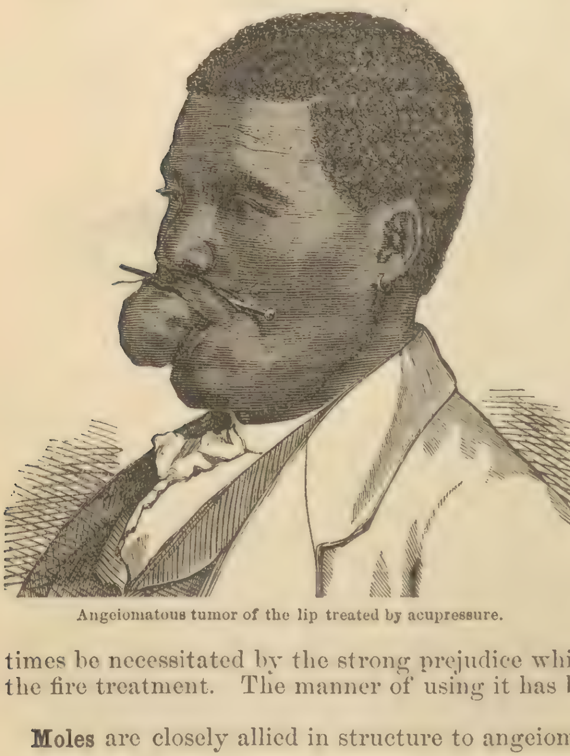
in both, after a time, there could be seen scarcely any difference or contrast in color between the previously discolored and the sound integument. Often the bleeding which follows the excision of a telangiectasis will be found to proceed from a single arterial trunk, which appears to be the only source of blood-supply. When excision, in any of its modifications, is adopted, the surgeon must not trench on the diseased part. All the incisions should be made in sound tissue, beyond the limits of the tumor, or at least exterior to its capsule; and if this caution be properly observed, these growths can be removed without any unusual hemorrhage, and with entire safety. In some cases it is practicable, after dissecting off the integument, to enucleate the diseased mass by the use of the fingers, the handle of the scalpel, and the forceps. When the angeioma occupies a limited part of the lip, and involves most of its structures between the skin and the mucous membrane, it is most satisfactorily treated by including the diseased part in a V-shaped incision, as in harelip, and uniting the margins of the wound with the figure-of-eight or twisted suture. When the tumor is too extensive for this operation, it should be subjected to strangulation by a number of double ligatures. In a case of angeioma of the upper lip, Professor Joseph Pancoast applied acupressure with success. (Fig. 359.) When situated in the parotid region, the tumor should be removed by excision; but when it is of unusual size, it will be safer to adopt the use of the actual cautery, introducing white-hot needles into the tumor, and repeating their application, at intervals of eight or ten days, until the growth becomes well atrophied. The thermo-cautery is an excellent instrument for applying intense heat, but is too expensive for general use. By some surgeons the seton is regarded as preferable to the actual cautery for the management of extensive angeioma of the parotid region, and its adoption will sometimes be necessitated by the strong prejudice which many entertain against the fire treatment. The manner of using it has been previously described.

Fig. 358.



A venous angeioma of the face which I treated by turning off the skin and strangulating the spongy mass beneath with a double ligature passed beneath its base with a needle.

Fig. 359.



Angeiomatous tumor of the lip treated by acupressure.

Moles are closely allied in structure to angeiomatous growths. They are

met with on the face, and over other portions of the body. They appear sometimes as deep-red spots, in which may be seen a number of very tortuous vessels. They remain permanent, showing no tendency to increase, are entirely harmless, and demand no treatment whatever. Sometimes they appear as flat elevations, having a brown or a chocolate color, caused by the pigment which they contain. These moles are frequently surmounted with hair, and in some instances are associated with great thickening of the skin. In the case of a young lady who recently consulted me for a deformity of this nature, the mole extended over almost one side of the face, and was covered with a strong growth of hair.

When these growths become a source of dissatisfaction, they may be excised, observing, as in the ordinary nævus, to keep beyond the limits of the diseased tissue. If the surface exposed be too large for approximation and suture, the surgeon must resort to a plastic operation to close the gap.

Angeioma of the Tongue.—The disease may be unilateral or bilateral; it may be confined to the anterior extremity of the organ, or may extend far back towards its root. It is easily recognized by the blue color, which can be distinctly seen through the mucous membrane, and by the soft, spongy character of the swelling, which can in a great measure be emptied of its blood by compression, but quickly refills on the removal of the pressure. A case of angeioma of the tongue, under my care, is steadily disappearing under the use of hypodermic injections of ergot: eight or ten minims of the fluid extract of this article, each minim representing one grain of the ergot, are introduced into the growth once every six or eight days. Should these injections fail, and the disease continue to increase, it must be removed by the écraseur, and if any bleeding follows, the vessels should be secured by ligature. The operation of strangulation by the ligature is attended with so much swelling of the tongue and with such an offensive discharge that it should be abandoned, endangering as it does the life of the patient from laryngeal œdema, from hemorrhage, or from blood-poisoning.

Angeioma of the Labium usually appears on the inside of the greater labium of young children, and may extend outwards to the thigh, or downwards to the perineum. Other portions of the vulva are not exempt from the disease. When situated in this locality, the affection is generally of the venous variety, and exhibits the same characteristics as when on other parts of the body. When the tumor continues to grow, its removal will be best accomplished by one of the several forms of ligature described.

Injuries and Diseases of the Veins.

Wounds.—Wounds of small veins are less serious than similar injuries of the arteries, chiefly because they are not so much under the influence of the heart's action, and consequently there is less danger from hemorrhage. When large venous trunks, like the subclavian, innominate, internal jugular, or axillary, are divided, death will follow in a few minutes from the loss of blood. The bleeding which proceeds from wounded veins in the neck is influenced very much by the respiration. During inspiration, when the walls of the thorax are dilated and no obstacle is offered to the passage of blood towards the right side of the heart, the wounded vein will remain partially collapsed, without shedding a drop of blood; but in expiration, when the great venous channels are compressed at the root of the neck by the diminished diameters of the chest, and there is a momentary arrest in the downward flow of the current, the blood will well up as from a fountain. In ligating a large vein, like the internal jugular, a certain degree of cerebral congestion must ensue from suddenly depriving the return circulation of so large a channel.

When a vein is severed, neither the retraction of the divided ends nor the

diminution in its lumen is so great as when an arterial trunk is divided across.

Incised wounds are the least harmful: they generally heal quickly, as is well exemplified in the rapid repair which follows venesection. Large veins only, when wounded, require the ligature; others are satisfactorily managed by pressure. Deep veins tolerate ligation better than superficial ones. I have frequently had occasion to tie the posterior tibial and popliteal veins after amputation at the knee-joint, and have never witnessed any unusual symptoms. Dr. S. W. Gross* has shown, in a paper on the ligature of veins, that the dangers after such operations have been perhaps unduly exaggerated. In wounds involving the chief vein of an extremity (for example, the femoral), and when the bleeding cannot be controlled by pressure, it has been advised by Langenbeck to tie the main artery rather than to ligate the wounded vessel. In a case of popliteal aneurism which had extended into the femoral region, and where, in consequence of an inflammatory adhesion of the parts, I wounded the femoral vein in passing the thread around the artery, the venous hemorrhage, which for a time was profuse, immediately ceased on tightening the ligature, and did not afterwards return. Under the circumstances this, I believe, was the proper treatment; but in ordinary wounds of the femoral, or of any other large vein, this practice should not be imitated: the damaged trunk should be exposed and tied above and below the seat of lesion. Some writers advise, in case the opening into a large vein is small, to stitch the orifice with a fine silk thread rather than to encircle the entire trunk of the vessel. The practice is a dangerous one, and altogether unreliable.

Veins not larger than those of the subcutaneous tissue will sometimes bleed persistently. In such cases the cause is usually some impediment in the flow of the blood towards the heart, and in their treatment the obstruction must be sought out, and, if possible, removed. In prolapsed hemorrhoids the grip of the sphincter will often cause a large loss of blood in a few minutes, which can be promptly controlled by dilating the muscle and returning the piles into the rectum. An enlarged liver may cause a free bleeding from the portal veins. Our remedies under such circumstances must be directed to reducing the size of the offending organ. Uncomplicated venous oozing is best corrected by the elevation of the part, and the application of cold, in order to diminish the force and activity of the circulation. A wounded vein, when surrounded with purulent fluid, may open an avenue for the introduction of septic matters into the system, which will seriously poison the blood. I have seen a trifling wound of the cephalic, below the line of the deltoid, prove fatal from this cause. Contusions of the soft parts are often followed by the laceration of veins, giving rise to dark discolorations or to ecchymoses, and sometimes to large collections of blood, which will remain in a liquid state for a long time. These accumulations should never be opened unless they terminate in abscess. Time and the use of stimulating applications, in order to quicken the absorbents, constitute the proper therapeutic measures.

Healing in veins.—The repair of wounds made in veins in no respect differs from the same process in arteries, a subject which has been treated of in the earlier chapters of this work.

Air in Veins.—The entrance of air into a vein is a most dangerous occurrence. Where the accident has taken place, it has been during operations upon the neck and in the axilla. Dr. Cordwent† reports a case in which he thinks death was caused by air entering the veins of the uterus after labor. That the veins of the neck should furnish most of the instances of this accident is doubtless to be ascribed to the fact that the venous trunks in this region are in many places attached to portions of the deep fascia, which prevents a collapse of their walls when wounded. The danger attending surgical operations from the entrance of air into the veins was first prominently

* American Journal of the Medical Sciences, January and April, 1867.

† St. George's Hospital Reports, vol. vi.

noticed by Beauchesne, in 1818. In several instances persons have perished from this cause while under the knife of the surgeon. Dupuytren lost a patient in this way while dissecting a tumor from the neck.* A similar accident befell Mr. Barlow while operating in the same region. Mott and Stevens each came near losing a patient from what was believed to be the admission of air into the circulation: in Mott's case, the vein opened was the facial. Death from this cause is said to have followed an amputation of the leg.† Professor Gibson, while extirpating a growth from the neck of a man before the medical class of the University, was startled by a gurgling sound and the sudden syncope of his patient. Though the case did not terminate fatally, the syncope was referred to the entrance of air into one of the veins.

Symptoms.—When air enters a vein, a whistling, hissing, or gurgling sound is heard; a deathly pallor spreads over the face; the pulse becomes small and feeble; the pupils are fixed and widely dilated; the respiration is short and hurried, and entire unconsciousness, convulsions, and fatal collapse follow.

Cause of death.—Several explanations have been offered for the cause of death in cases of the above accident, but none of them are altogether satisfactory. Examinations after death show air in the right side of the heart, an unusually bloodless appearance of the lungs, and in the left auricle and ventricle a small amount of blood intermixed with air, giving it a frothy appearance. The same fume or frothy admixture of blood and air is seen in the arteries and veins of both the pulmonary and the systemic vessels. Among the most plausible explanations is that which supposes that the air, after entering the right auricle, is carried to the right ventricle, and that during the contraction of the right ventricle the presence of the air prevents the closure of the tricuspid and semilunar valves, in consequence of which the two openings which they guard remain pervious in both the systole and the disatole of the heart, allowing the air to reach the pulmonary arteries, and in this way preventing the entrance of blood.

Treatment.—In view of the possibility of so fatal an accident, the surgeon should be exceedingly careful in all operations involving the deep portions of the neck or of the axilla, and, especially when prying out adherent growths from these regions, should have firm pressure made by assistants upon the contiguous veins, both above and below. In the event of air gaining access to the circulation, the head should be immediately lowered, the respiration should be maintained by artificial means, using either the "ready method" or electro-galvanism, brandy should be administered by the rectum or subcutaneously, and, as a last resort, if time permit, a few ounces of blood may be transfused.

Phlebitis.—There are two kinds of inflammation of the veins, the *idiopathic* and the *traumatic*. Either is more common than arteritis. The veins most commonly involved are the saphena magna, the femoral, and the pelvic trunks. The disease may appear in both the acute and the chronic form.

Causes.—The causes of phlebitis may be arranged under the following heads:

1. *Ectasis;* that is, from the extension or overstretching of the walls of the vessel, in consequence of which, the movement of the blood being retarded and the mechanism of the valves impaired, a coagulum or thrombus is formed, the presence of which is prone to excite inflammation in the walls of the disordered vessel. This condition may occur in persons enjoying good health, and the inflammatory changes may be entirely local. Persons whose employments require the standing position are liable to such thrombi, particularly if at the same time they are exposed to cold. Pressure from abdominal tumors will give rise to the same coagula.

2. *Traumatism.*—Under this head are included cuts, lacerations, bruises, and

* Medico-Chirurgical Transactions, vol. xvi.

† Medical and Surgical History of the British Army in Turkey and the Crimea, vol. ii. p. 277.

punctures. The frequency of such injuries without the occurrence of phlebitis shows that there is in the healthy condition of the blood and of the solids a strong indisposition in the veins to take on inflammation. The rapidity with which a vein heals after venesection, or after the ligature of a hemorrhoidal tumor, is additional proof of this fact. It is in these traumatic cases that the surgeon occasionally witnesses the extension of the disease in a direction opposite to that of the circulation. This fact, first noticed by Hunter, is doubtless due to a mechanical cause,—to coagula formed in the tributaries of the injured vein.

3. *Constitution of the blood.*—After typhoid fever, typhoid pneumonia, scarlatina, and other affections attended with alterations in the constitution of the blood, it is not uncommon to meet with phlebitis from obstruction of the saphena and other veins by the formation of clots. It is often after the violence of the disease has expended itself and convalescence commenced that these thrombi form. To the same category of blood-change are to be referred those cases of inflamed veins which occur in gouty and rheumatic states of the system.

4. *Introduction of septic matters.*—The effect produced on the blood by the introduction into the veins of certain products connected with textural change is of such a nature as to cause coagulation, or to excite those inflammatory changes in the walls of the vessels which induce the formation of a clot. This condition is closely related to pyæmia or septicæmia. Such materials effect an entrance into the vessels not by being absorbed, but by passing directly into the current of the circulation through an opening in the injured veins. Thus, we find that when surgical operations are done in structures where the walls of the veins, being adherent to the surrounding parts, do not collapse, as, for example, in the cancellated tissue of bones, symptoms of septicæmia are frequently developed. Pyæmic conditions following the puerperal state are caused in the same way, as the large patulous uterine sinuses invite the entrance of vitiated matters.

5. *Continuity of tissue.*—The continuity of the connective tissues renders it easy for inflammation to extend from one point to another, and hence when phlegmonous erysipelas attacks a part, or when the loose connective tissue contiguous to a vein becomes inflamed, the disease may very readily be conducted to the coats of the vessel and cause the deposition of a solid plug in their canals.

It will be seen from the above remarks that the existence of a thrombus plays a very important part in the production of phlebitis. Sometimes it antedates the inflammation and becomes an exciting cause of the latter. At other times it succeeds it, and is an effect of those changes which occur in the walls of the vein, especially in the tunica intima, which I am led to believe has most to do with thrombosis.

The late Professor Charles D. Meigs attributed to the internal coat of the blood-vessel system, or to the endangium, as he termed it, a paramount influence over the blood. The changes which the clot or thrombus undergoes vary greatly in different cases. When the clot follows some injury, or when, as from the application of a ligature to a venous trunk, its object is a salutary one, designed to establish a barrier against the intrusion of harmful materials into the circulation, the coagulum will extend in both directions to a collateral or tributary branch, into which it will pass. Sometimes it is not limited by such side-channels, but is continued upwards and downwards, blockading an entire vein and its branches. The obstruction is not always complete. The thrombus may contract, maintaining its connection only to one portion of the vessel, and allowing a side-passage, which will admit the onward flow of the blood. Or the clot may, by the agitation to which it is subjected from the blood-stream, become decolorized, forming a plug of fibrin, through the centre of which are often tunneled one or several openings for the current of the circulating fluid. The final disposition of the thrombus is not always the same. It may undergo organiza-

tion, as does the clot which forms in an artery after its ligature (see page 156), and become blended with the walls which inclose it, the whole finally being converted into a fibrous cord; or it may soften down, and become changed into a bland, impalpable fluid, which will consort harmlessly with the blood and be removed out of the body. Unfortunately, these disintegrations of a clot do not always vanish in so innocent a manner. Fragments may separate from the common mass and be swept along in the circulation to the right side of the heart, and, after passing into the pulmonary artery, become impacted in the capillary vessels of the lungs, giving rise to metastatic inflammation and abscess; or the thrombus may degenerate into a puriform-looking fluid, consisting of altered red and white corpuscles and of granular matter, which, mingling with the blood, acts as a ferment, and not only perpetuates and extends the phlebitis, but also induces a fatal septicæmia.

Symptoms of Acute Phlebitis.—Acute phlebitis is characterized by tenderness along the course of the affected veins, by the existence of peri-venous thickening, so that they have a cord-like feel under the finger, and by œdema and venous congestion, the result of an impeded or obstructed circulation. When the affected vessels are superficial, lines of a dusky-red color may be seen in the course of the inflamed trunks. The entire limb becomes stiff and supersensitive, and the temperature falls below the natural standard. More or less constitutional disturbance is always present; indeed, it often begins coincident with the local affection, manifesting itself by rigors, fever, a frequent pulse, headache, thirst, nausea, dry tongue, and sometimes by the presence of delirium.

Diagnosis.—Phlebitis may be confounded with angeioleucitis. In the latter, however, there is no œdema, and the lines of color are both narrower and redder than those present in inflammation of the veins. In angeioleucitis the lymphatic glands, in direct communication with the affected absorbents, are usually tender, and more or less swollen.

Pathology.—In phlebitis, the earliest inflammatory changes commence in the connective or adventitious coat of the vein, and consist of congestion in the vasa vasorum, and of transudation, producing redness and swelling in the course of the vessels. This transudation may be largely serous, or it may be fibrogenous and contain a large number of young cell-forms; it interpenetrates the middle and inner coats of the vein, separating their layers, and, by the new formation of connective tissue, induces such a degree of thickening as entirely to destroy the normal elasticity of the vessel and convert it into a rigid sclerosed tube. Should the inflammation prove less intense, the infiltration may be gradually absorbed, and the natural pliability of the walls of the vessel be restored. When the disease advances to suppuration, there is induced a serious alteration in the histological elements of the vein-tissues, a change not peculiar to these vessels, but common to all tissues when under inflammatory influences,—that is, molecular disintegration and a fatty metamorphosis,—changes which prove destructive to the internal in common with the other coats of the vein. The production of a clot, as one of the effects of inflammation in a venous trunk, has been already noticed.

Acute phlebitis, arising in bad constitutions or in persons who have been greatly enfeebled by exhausting disease, may assume a course which has been called *diffuse phlebitis;* or it may originate in an attack of phlegmonous erysipelas, the inflammation extending from the subcutaneous connective tissue to that in which lie the imbedded veins, and thence to their walls proper, terminating in a diffused suppuration, which extends between the coats and travels along the sheaths of the vessels, causing their softening and disorganization, together with the formation of thrombi. These softened clots, intermingled with the vitiated products of inflammatory changes, enter the circulation and destroy the patient from pyæmia.

The symptoms accompanying this form of the disease are local tenderness and redness in the course of the hard, thickened vein. When the vessels involved are deep-seated, these signs are not present; but when tenderness is

experienced on firm pressure being made over the position of the profound veins, when the limb is enlarged and dense, but does not pit under the finger, and when there are present rigors, a feeble, frequent pulse, sweatings, a brown, dry tongue, a sallow countenance, with accumulation of sordes about the gums, and diarrhœa and delirium, the diagnosis may be established with considerable certainty.

Treatment.—The treatment of phlebitis differs according as the superficial or the deep veins are affected. In that variety (idiopathic) which is often seen succeeding an attack of typhoid pneumonia, typhoid fever, or gout, and involving the subcutaneous veins, no remedy in my experience is equal to the local abstraction of blood. A few American leeches placed along the course of the inflamed vein will quickly diminish the pain and extreme tenderness of the parts, after which the limb should be wrapped in a lotion of lead-water and laudanum and covered with oiled silk. As soon as the redness and undue sensibility subside, the compound solution of iodine with laudanum, brushed daily over the entire length of the diseased vessel, will form the most effective application. In traumatic injuries, especially when followed by pronounced shock or when the person is broken in health, much may be done in the way of preventing phlebitis. As the disease sometimes originates in an extension of inflammation from the surrounding connective tissue, the utmost care should be observed to evacuate any abscesses which may arise, to secure thorough drainage, and to see that no foreign matter in the wound is overlooked. When inflammation attacks the deep veins, even though early discovered, the local abstraction of blood does not appear to exercise any beneficial effect in controlling or ameliorating the disease. The constitutional treatment consists in removing by a gentle cathartic all sources of intestinal irritation, relieving pain by anodynes, and supporting the patient's strength by the use of tonics and stimulants, such as iron, quinine, brandy, whisky, or wine, and by the most nutritious preparations of food. If in the course of the disease a vein becomes opened by ulceration, causing hemorrhage, the flow of blood can be controlled by a well-adjusted compress and roller over the seat of lesion.

Chronic Phlebitis.—The subjective nature of the symptoms in chronic phlebitis often allows the disease to exist for some time without being recognized and until considerable structural change has taken place. Veins whose circulation is much under the influence of gravity, as those of the inferior extremity and of the rectum, are most commonly the subjects of the disease. This is explained by the resulting dilatation causing congestion in the venous trunks. In those of the rectum, the absence of valves forms an additional incitement to congestion. Such inflammation is not necessarily connected with thrombosis, as we constantly witness the disease in the varicose veins of the leg without the production of clots. Chronic inflammation of veins may succeed the acute form of the disease. The morbid alterations of structure in chronic phlebitis are not unlike those observed in other tissues under a similar process. There is increased thickening of the external and middle coats, partly by migrated forms and partly by the proliferation of the connective elements of the parts. In these changes the tunica intima appears to escape. Cornil* locates the chief thickening between the internal and middle coats. As in chronic inflammation elsewhere, so here, the obstruction to the circulation from surrounding induration causes dilatation of the intrinsic veins of the walls until they become enlarged into sinuses. As chronic phlebitis occasionally follows the acute, the converse is likewise true, in which event coagula will form, and the patient will be exposed to the risk of their future metamorphosis.

Treatment.—The chief indications are to overcome the obstruction to the circulation, control the inflammation, and effect the removal of the plastic deposits in the tunics of the vessels. To favor the passage of the blood, the

* Archives de Physiologie, 1872, p. 602.

limb should be elevated; to subdue the inflammatory action, leeches and blisters, followed by the application of Lugol's solution of iodine, are the most potent agents; and for the removal of the thickening, warm-water irrigation, associated with compression by a roller bandage, promises the best results.

Hypertrophy.—This change in the walls of a vein may originate in a chronic inflammation such as has been described, or it may be purely a physiological necessity, resulting from a plenum of blood. In the first instance there is an organization of the transudation into connective tissue; in the other there is an increase of growth in the elements of the different coats, particularly the external and the middle, in consequence of which there follows a uniform or symmetrical enlargement in the walls and in the canal of the vein, the latter becoming lengthened and tortuous. The capacity of the veins for physiological hypertrophy is one of those wise provisions for extraordinary occasions which are so often witnessed in the human body. If a tumor or a clot obstruct the iliac vein, the superficial branches of the femoral are very soon seen over the abdominal walls, enlarged and tortuous, in order to supplement the office of the disabled channel. A growth in the axillary region compressing the axillary vein is quickly followed by an unusual prominence of the subcutaneous vessels over the thorax. The most notable example, however, of an amplification of the venous channels to meet a temporary emergency is that seen in the gravid uterus, in which the veins almost completely inclose the organ in an intricate net-work of enormous blood-channels. With hypertrophy of the veins there is generally associated an enlargement of the companion arteries, a singular illustration of the effort made by nature to maintain a just balance between the two systems of vessels.

The treatment of cases of venous hypertrophy consists in removing the causes of obstruction whenever possible. Thus, if a tumor compresses a large vein, it should be removed, provided the growth is one adapted to an operation; and when the pressure is due to inflammatory infiltration, the latter must be got rid of by blistering, *massage*, compression, and alteratives, among which latter mercury and the iodide of potash rank highest.

Atrophy.—Veins may become atrophied in consequence of the sclerosis which sometimes follows inflammation, and also from diminished functional activity. If a limb be kept in a state of rest for several weeks, as in a case of fracture of the leg, the tissue-demand for blood is greatly lessened, and there will follow an appreciable wasting in all the vessels of the extremity, but chiefly in the veins. It is this diminished capacity in the venous system of the limb which causes the distressing sense of stuffing experienced by the patient when he first re-assumes the erect position, the veins being temporarily disqualified to return with due celerity the suddenly-increased volume of the circulating fluid introduced by the arteries. Atrophy of any organ is attended by a corresponding change in the veins which supply it. The atrophy of many tissues is accompanied with fatty degeneration of their normal components, a metamorphosis from which the veins are markedly exempt, calcareous transformations being much more common.

Phleboliths.—Small, round, or oblong bodies are met with in veins, either lying loose in their canals or attached by a delicate thread of fibrous tissue to their walls. These bodies are probably formed by the calcification of a blood-clot, and are chemically composed, as has been ascertained by Dr. Frankland,* of albuminous and fibrinous matters, conjoined with phosphate of lime, having also a trace of sulphate of potash and sulphate of lime, all of which materials are furnished by the blood. These bodies manifest a preference for particular veins, such as the prostatic and the vesical. They are occasionally found in old varicose vessels.

* Holmes's System of Surgery, vol. iii. p. 373.

The veins are rarely the subject of carcinoma. Virchow* describes a giant cell myosarcoma which originated in the inferior vena cava. The case is, perhaps, unique. A carcinomatous tumor originating in the vicinity of a vein may finally include the vessel, destroy its walls, and send portions of the rapidly-proliferating outgrowths into its cavity, giving it the semblance of a venous cancer.

Varix.—The terms varix, varicose veins, and phlebectasis are used to express a condition of certain parts of the venous system in which the vessels are dilated, elongated, tortuous, and knotty. Though most of the veins are susceptible of such alterations in structure and form, the disease for the most part is limited to the spermatic, pudendal, and hemorrhoidal veins, and to the saphena veins of the lower extremities. (Fig. 360.) Varix of the veins of the upper eyelid is occasionally seen. Rokitansky describes a varicose condition of the veins of the pia mater met with in persons of intemperate habits. The same writer speaks of a similar condition of the veins of the choroid plexus. A peculiar configuration of the vessels around the umbilicus has been noticed, due to the existence of a communication between the superficial veins of this region and an inclosed umbilical vein, constituting the caput Medusæ of Severinus. The superficial pudic and mammary veins occasionally become dilated. (Fig. 361.) Varices of the veins of the neck have been described by Morand, Cline, and Roux. In the thorax the intercostals have, in rare instances, been seen dilated and tortuous; and Portal records examples of a similar condition of the vena azygos. Even the superior vena cava, according to Morgagni, may become the subject of the disease. Cases are on record of enlarged and convoluted veins in the abdomen. In the pelvis, the veins at the neck of the bladder (prostatic) and those of the rectum are frequently found varicose; the first often giving rise to vesical hemorrhage, and the last constituting piles. Only once have I seen true varices on the upper limb; but Roux, Cartier, and others describe cases of this kind. Though the disease was familiar to the ancient medical writers, yet none, it appears, were ever apprised that any other than the superficial veins were affected. That these should suffer and the deep trunks escape was referred by Boyer, Sir Everard Home, and others to the slight support rendered by the skin and subcutaneous fascia to the former, while the latter received a strong support by muscles and the prolongations of the deep fascia. That this view is incorrect has been satisfactorily shown by

FIG. 360.

Varicose disease of the saphena magna.

FIG. 361.

Varicose state of superficial veins of the abdomen.—From Bryant.

* Virchow's Archives, Bd. lii., 1871.

Verneuil, who found that the dilatation often begins in the deep veins, the subcutaneous trunks becoming secondarily affected; a fact which I had ample opportunities to verify some years ago, when engaged in teaching anatomy. Mr. Gay thinks that the arterial trunks are implicated in varices; an opinion in which, I believe, few writers concur. Except where there is some mechanical pressure near the entrance of a subcutaneous vein into a larger trunk,—as that of the saphenous into the femoral,—I believe it will be found that in all cases of varices of the leg the deep veins, as well as those which establish a connection between the two sets, are affected similarly to the subcutaneous ones, and in all probability take precedence in the dilatation.

Causes.—In general, whatever obstructs the flow of blood towards the right side of the heart, causing over-distention of the walls of the great veins, favors the formation of varices. Among these causes may be enumerated the following:

1. *Organic affections of the heart*, such as disease of the semilunar valves of the pulmonary artery or of the aorta, and imperfection of the mitral valves; conditions which favor pulmonary congestion by interrupting the free transit of the blood through the lesser circulation, and thereby causing engorgement of the cavæ and smaller vessels.

2. *Obstruction in the portal system.*—The deleterious effect of an impeded blood-flow through this part of the venous system is more concentrated than when a like cause operates on the other system of veins. In the former the hemorrhoid veins suffer most. Thus, in sclerosed conditions of the liver (cirrhotic liver) piles are very commonly present.

3. *Pressure upon the great veins within and without the body* constitutes another very common cause of varix. This pressure may be made by the gravid uterus resting upon the cava or on the iliac veins; by an ovarian or a uterine tumor; by aneurism of the abdominal aorta; or by fæcal accumulations in the colon. The pressure which operates externally in retarding or obstructing the venous circulation is often due to the existence of a tumor in the groin resting over the femoral vein, or to a constriction of the limb by a tight garter. Again, a long continuance in the upright position may lead to dilatation of the veins from the action of pressure: hence we often meet with varices in persons whose occupations require them to be on their feet for most of the day. In this position, the pressure of a long column of blood like that in the saphena vein of the leg is very great.

4. *Diminished accommodation for the venous circulation* is another factor in the production of this disease; that is, when one or more veins have been rendered useless by their channels becoming blocked up with coagula from inflammatory or other causes, thereby making an increased demand on the remaining vessels to supplement the deficiency. The force resulting from this addition to the volume of their usual contents is exerted upon the sides of the overtaxed veins, in consequence of which they become varicose. It is in this way, most probably, that deep-seated contusions of the lower extremities act in developing varices, as many of the veins are, subsequent to such injuries, lost to the circulation by inflammatory changes or by sloughing.

5. *Trades and occupations*, regarded by some as causes of varix, except, perhaps, such as demand for their prosecution the standing position, exercise little influence in causing the disease; and the same may be affirmed of constitutional temperaments.

6. *Hereditary predisposition* to phlebectasis is said by Hasse* to exist; and I think his views on this subject are borne out by clinical observation.

7. *Sex and age.*—Some writers believe that males, and others that females, are most liable to the disease. There may be something connected with the social and industrial life of the sexes in the different nations which will explain the diversity of opinion on this subject among British and French

* Cooper's Surgical Dictionary, article "Varix."

authors; but I am disposed to believe that in this country the two sexes are equally the subjects of this disease. The influence of age in determining the formation of varices cannot be questioned; for while the affection may occasionally be witnessed in children and in aged persons, the middle period of life is that in which varicose veins are most commonly contracted.

The principal reason for varix being generally confined to the lower extremity is that the contents of the veins tributary to the inferior vena cava are very much under the influence of gravity, being far removed from the centre of the circulation.

Pathology.—The changes which occur in a varicose vein are such as affect its form, the structure of its walls and of its valves, and the peri-venous connective tissue.

Form.—I need not speak of those varicosities of the minute skin-veins, which are often seen scattered over the leg in straggling lines of a light-blue or a purple color. These varices are quite harmless, rarely give any inconvenience, and, indeed, seldom develop into the more aggravated form of the disease. When the superficial veins of the leg have to sustain an unusual degree of blood-pressure, either from obstruction in the course of their main trunks or from the blocking up of a neighboring channel, requiring them to supplement the deficiency, their walls become stretched, and their canals correspondingly dilated. The effect of these changes is to thin the coats of the vein and to diminish its power to resist the internal pressure. At this stage of the disease (taking the internal saphena as the subject of our description), a number of soft, compressible, blue swellings, very noticeable when the patient is standing, appear over the inner part of the leg and the foot. The effect of this distention of the veins is to produce a plenum of blood in the capillaries with which they are connected, and thus cause a transudation of serum and of white corpuscles, not only into the fibrous material which encompasses the veins, but also into their tunics. The dilatation up to a certain point is usually quite uniform, the vessels being straight and cylindrical, but as the disease advances they become elongated, are thrown into serpentine flexures, and develop sacculated projections, giving them a tortuous and knotty appearance. This convoluted and elongated condition of varicose veins is usually regarded as the result of interstitial growth; but more than this is necessary for its explanation. The effect of dilating an elastic tube of dead matter will be to shorten, not to lengthen, its canal. A living tube like a vein is subject both to vital and to physical laws, and therefore the analogy fails in this particular; but the operation of the former does not exclude, it only modifies, the action of the latter. Indeed, in many respects the physical forces dominate the vital, both in normal and in abnormal growth. In explaining, therefore, the convoluted form of the veins, it is necessary to remember that the infiltration in their walls and in the surrounding connective tissue forms hyperæmia, the effect of over-distention, that it is not equally disseminated, but exists at some points to a greater degree than at others, and that the new cell-elements of the transudation becoming transformed into connective tissue give rise to a like inequality in the thickening of the coats of the veins. (Fig. 362.) This thickening in the walls of the vessel is chiefly confined to the middle or muscular coat, and is produced not by an increase in the number of muscle-cells, but by the addition of white corpuscles, which ripen into connective tissue. This unequal distribution of the nutrient elements renders the vein weaker at some portions than at others; and it is at these weak or thin parts that the walls first yield, causing a slight

Fig. 362.

Longitudinal section of a vein, showing the unequal thickening of its walls.

lateral deviation in the course of the vessel, which, in consequence of a similar change in the direction and force of the blood, is increased more and more, until a marked curve or convolution is formed in the vein. The effect of one curve is to reflect the circulating current forcibly against an opposite and higher point of the vein, and to cause another curve in that direction. A bed may be cut for a stream of water whose sides shall be geometrically parallel with each other, and yet, if left unrestrained by artificial barriers, it will soon groove out for itself a channel like the trail of a serpent, simply because a slight indentation was formed on the side of one of its banks. The same law is in operation to produce the curves in a varicose vein.

Another structural change is one affecting the valves of the enlarged veins. Mr. Gay says that veins which become varicose are generally without valves, a statement in which I do not concur. The effect of dilating the venous canals is to separate the cusps so widely that they are no longer capable of commanding the channel which they are designed to guard, and are pressed forcibly on both surfaces,—on the upper side by the weight of a column of blood which presses backwards, and on the distal side by the stream of blood moving towards the heart. The conjoined influence of distention and pressure either causes their atrophy and final disappearance, or, from their extreme tenuity, produces laceration, converting them into a number of floating threads. In some instances where dilatation of the diseased vein advances very gradually, the valves increase *pari passu* in strength, becoming markedly hypertrophied, and executing their functions unimpaired. From the very commencement of the disease the peri-venous connective tissue participates in the morbid changes. It is at first infiltrated with serum, giving rise to a slight œdema in the course of the dilated vein, and later is crowded with migrated leucocytes, which become developed into connective-tissue corpuscles, and finally into true fibrous tissue, the condensation of which increases the thickening about the veins, glues firmly together their convolutions, and fills their cavities with coagula. This infiltration of the connective tissue, inflammatory in its nature, sometimes extends far beyond the limits of the affected vessels, involving the lymphatics and the subcutaneous fascia of the limb, producing a general hypertrophy of the connective tissue, and forming a pseudo-elephantiasis. Instead of the walls of varicose veins and the surrounding connective tissue becoming hypertrophied, a change of an opposite nature is frequently induced; the veins become attenuated, and the connective tissue for the most part disappears, the vessels contracting an attachment to the skin. Under such circumstances pouch-like protrusions appear over the limb, which, when the person is standing, present a blue appearance.

Symptoms.—Varix may arise so gradually that the patient is unable to fix the period of its commencement; but generally there are some precursory signs which foreshadow the disease. The most common are an unwonted fatigue and fullness of the affected limb or limbs, experienced after walking or after long standing. These sensations are often associated with a slight swelling or œdema about the ankles, and with numbness of the leg. After a time a slight blue protrusion appears in the course of the internal or the external saphenous vein at a point where a tributary branch enters a main trunk. Obstruction to the current here is immediately realized in the contiguous veins, which in turn become dilated, and in this way the circle of embarrassed circulation and dilatation extends, causing a tortuous and knotty condition of the veins, involving more and more of these trunks of the leg (Fig. 363), until the entire venous system of the limb may participate in the disease. In the recumbent position, or when the leg is elevated, the swollen vessels disappear, or become much diminished, but they quickly reappear when the patient stands upon the feet.

Effects.—A very common sequence of the embarrassed circulation in a limb affected with varix is eczema. The surface becomes inflamed, and minute

vesicles are formed, which open and pour out a thin serum, which keeps the parts moist, or, mingling with the detached cuticle, desiccates into scales.

Varicose ulcer.—A similar state of the circulation frequently develops an inflammation, which results in ulceration and the formation of the varicose ulcer.

Hemorrhage.—The venous distention may thin out both the walls of the vein and the tissues immediately around, until the parts become so weak that a slight bruise, or a little additional pressure, consequent on standing, will cause a rupture of the varix and the effusion of a large amount of blood. In addition to the above, stiffness of limbs, burning in the feet, and cramps of the legs are frequent attendants of the disease.

Fig. 363.

Varicose condition of the saphena interna.

Treatment.—Where the cause producing varix is of temporary duration, such as pressure from the gravid uterus, or from a removable tumor, abdominal or otherwise, great relief will be experienced when the cause ceases to exist. Much may be done to relieve obstruction in the dilated vessels by avoiding the use of garters, by regulating the bowels, when costive, with saline aperients, thus preventing an over-fullness of the portal system, and by administering ferruginous tonics, with cold bathing, when the patient is weak and his muscular fibre relaxed. When varix of the leg is thoroughly developed, surgery, though it possesses no means of cure, is capable of affording a degree of palliation which will render the patient entirely comfortable. With this object in view, local compression should be applied. This remedy, though commonly recognized as that of Delpech and Sanson, is really as old as Avicenna. It may be made by adhesive strips, by the roller alone, or by the elastic stocking. The latter will furnish the most expeditious means of imparting a uniform support, and will be found the most convenient dressing to wear. It should never, as is too commonly the case, be applied next to the skin, as the perspiration will quickly impair its value by rendering the fibre of the stocking rotten and by destroying its elasticity; neither should it be worn without including a considerable portion of the foot. The limb should be elevated so as to drain the blood out of the distended varices, after which a very thin cotton, linen, or silk stocking, long enough to reach to the knee, must be slipped on the leg, and over this is to be drawn the elastic stocking. (Fig. 364.) When the patient retires at night, this dressing must be removed, and the limb bathed in cold water and afterwards subjected to brisk friction with a woolen cloth. In the morning, the stocking should be replaced before the patient rises to his feet. In the absence of the elastic hose, the ordinary laced stocking, shown under the head of surgical dressings, may be substituted with advantage. When the veins of the thigh participate in the disease, the elastic stocking should be continued up to the groin (Fig. 365), a piece of thin muslin being interposed between the skin and the dressing. The roller may be used in different ways, as an ordinary spiral reversed of the lower extremity,—always remembering to raise the limb before its application, and to make the

Fig. 364.

Elastic stocking applied.

turns with the utmost uniformity of pressure,—or as an immovable dressing. In the latter form it is necessary, after emptying the vessels by position, first to make the spiral reversed of the limb, and then over this to place a second roller, which should have brushed into its pores boiled starch or liquid glass (silicate of soda); or the second may be a plaster roller, which will require to be dropped into a basin of water for a few minutes previous to its application. The immovable dressing will in a short time become firm and hard, and may be worn continuously for several weeks. Adhesive straps, recommended by Travers, are well suited to varices located about the ankle, and should be used in the same manner as when employed for the cure of leg-ulcers. (See page 122.)

Fig. 365.

Elastic stocking including the entire limb.

Various operations have been vaunted from time to time for the cure of varices. Among these may be mentioned laceration, cauterization, excision, incision, seton, ligature, caustics, electro-galvanism, and injection. Laceration is an old Roman operation, and consisted in exposing the vein and tearing it across by traction. Cauterization was practiced by Celsus: the diseased vein was laid bare by dividing the skin, and the hot iron applied directly to its walls. Excision is likewise an ancient measure. It was practiced by Celsus, though confined to the treatment of veins which were only slightly tortuous. It was revived by Boyer and Richerand, but fell into discredit and disuse. Lisfranc at a later period attempted the operation in a modified form. Very recently, it is said, this operation has been repeated on the saphena magna.* Incision was tried by Paré and Petit. The seton, recommended by Fricke, consisted in passing a thread a number of times through the vein and allowing it to remain for several days. Davat had attempted to obliterate veins on the same principle, by inserting two pins at right angles across the vessel and binding them together with a thread. The ligature of varicose veins has at different times attracted considerable attention. This method was employed by Paulus Ægineta, Ambroise Paré, Boyer, Béclard, and Sir Everard Home. Boyer combined incision with the ligature, first tying the vein in two places and laying it open between the threads. Dupuytren tied the vessel with a single thread and cut the vein across above the ligature. Sir Everard Home exposed the vein and placed a thread about it, hoping for the obliteration of its canal without division by the knife. Brodie, instead of ligating the main trunk of the affected vein, placed his ligatures upon its principal tributaries. Subcutaneous section of varices was first introduced by this surgeon. Ligation was effected in a different way by Velpeau. A pin was first passed beneath a single vein, or beneath a group of convolutions, and a figure-of-eight turn made by carrying a ligature about its extremities. The surface of the skin was protected against ulceration by interposing a section of a bougie between the threads and the skin. Professor Hamilton selects one of the largest veins at the inside of the knee, passes beneath it a needle armed with a thread, and then, placing over the skin a little pledget of lint to defend the integument from pressure, ties the two ends of the ligature firmly together. A second inclusion of the vein is made in a similar manner, one or two inches above the first. These ligatures are repeated eight or ten times, until all the principal trunks have been secured. In seven or eight days the threads will have cut their way to the surface by ulceration, and may be removed. Poultices of flaxseed-meal are applied over the parts, and a recumbent position is maintained during the treatment. Mr. Lee, like Velpeau, used the pin and the figure-of-eight suture, but with this difference, that he introduced

* Ziemssen's Cyclopædia of Practical Medicine, vol. vi. p. 501.

two such sutures, and subsequently made a subcutaneous division of the veins included between the needles. Dr. Levis, of this city, has in a number of instances ligated varicose veins by a subcutaneous loop of silver wire. Sanson and Startin endeavored to substitute the ligature by applying destructive compression in another way,—the first by grasping the vein together with the integument by spring forceps, and the latter by a bar-needle and clasp.

Caustics have enjoyed considerable popularity, and are still regarded with favor by some surgeons. They act by inducing coagulation of the blood in the vein over which they are placed. The particular agents of this class which have been recommended and used are the Vienna paste, caustic potash, and nitric acid. The Vienna paste was a favorite caustic with Bérard, Skey, and Mayo, and in this country with Professors Pancoast and Gross; it is the only remedy of the kind which I have ever used for the purpose under consideration. It is prepared by mixing five parts of quicklime with four parts of caustic potash, and converting the mixture into a paste with spirits of wine immediately before using. The method of applying the agent is to take several small patches of adhesive plaster and cut in each a little perforation. These are to be applied, at short distances apart, over the course of the principal vein or veins, and the little openings filled with the paste, each being afterwards covered with a second patch of plaster. The caustic causes sloughing of the skin over the vein, filling the latter with inflammatory clots. In France, the paste of Canquoin, which consists of equal parts of chloride of zinc and farina, moistened with water, has been very largely employed in varices. Verneuil states that it has been used in over two thousand cases without a single accident.

Electro-galvanism has been employed by Capaletti,* and in this city by Dr. Grier, with a view to obliterate the vein-canals by inducing thrombosis.

Injection of the veins with perchloride of iron has been practiced in France to a considerable extent, and, it is alleged, with very satisfactory result. The injection is accomplished by means of a small glass syringe and a very delicate trocar and canula.† The contact of this salt of iron with the blood causes the formation of a solid clot in the cavity of the vein; and before the injection is made, a firm bandage must be placed on the limb above, and retained there for some time, with the double object of making the vessel prominent, and of preventing the stream of blood from detaching and carrying a fragment of the clot to the heart and the lungs.

It will be perceived that the object in all these multiplied operations is one and the same, namely, the obliteration of the diseased veins. The objection which has been urged against most of them is the risk of a diffused phlebitis, erysipelas, etc. While it is true that in a number of instances death has followed from these causes, yet the danger arising from tying and otherwise meddling with veins has been doubtless very much exaggerated. In my opinion, all these procedures, when applied to the veins of the leg, are not only unphilosophical but also injurious. To deprive the venous system of an important trunk like the saphena is to turn an undue amount of blood into neighboring veins and produce in them an increased dilatation. According to my own observations, in cases of varix operated on by myself with caustic, and in others which I know had been treated with the ligature, the disease has invariably returned. I do not, therefore, believe that any operation which has yet been devised for the radical cure of varices is entitled to professional confidence.

Diseases and Injuries of the Arteries.

The arteries possess a wonderful facility for eluding injury. This is to be referred to several causes: 1, to position, the vessels being generally deeply situated, and occupying the least exposed localities of the body; 2, to the

* Archives Générales, 1848.

† Mémoires de la Société de Chirurgie de Paris, vol. iv.: paper by M. Desgranges.

elasticity of their walls; 3, to mobility in their sheaths, and in the loose cellular tissue with which they are surrounded; and, last, to the protection of contiguous muscles, which serve to deflect vulnerating bodies. Wounds of the large vessels are not very common in civil practice.

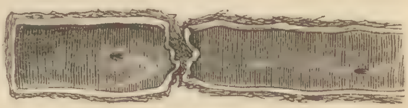
Contusions, though most common in gunshot wounds, may occur from other kinds of violence. The resulting inflammation may terminate in one of three ways: first, in the narrowing and even the obliteration of the lumen of the vessel from the contraction of its tunics, or, secondly, in the formation of a coagulum obstructing its channel,—in either case causing mortification of the parts below unless the collateral trunks are equal to the task of transmitting the blood; thirdly, in ulceration, thus establishing an opening in the artery and giving rise to dangerous hemorrhage.

Treatment.—Should mortification follow a contusion of the artery, it will not be necessary to wait for the line of demarkation, but the limb should be immediately removed above the seat of lesion. When ulceration takes place, followed by hemorrhage, a ligature should be applied above and below the opening in the vessel.

Lacerations may be complete or incomplete, and may occur with or without an external wound. In complete laceration—an accident of frequent occurrence in manufactories—the artery is torn entirely across; and the injury is usually accompanied by extensive contusion and laceration of the soft parts.

Incomplete lacerations are those in which the internal and middle coats are torn, and the external tunic remains intact. (Fig. 366.) The lacerated layers curl inwards upon themselves, and may block up the lumen of the vessel. The current of blood after such an injury is liable to stretch the external coat of the artery into an aneurismal sac, or, by getting in between the coats, to detach them from one another for a considerable distance, constituting the *interparietal* or dissecting aneurism. Another form of laceration, but a rare one, is where the external and, it is said, even the middle coat is severed, the internal one alone remaining sound. It is highly probable that in this very uncommon injury some of the muscular and elastic fibres remain, since otherwise the delicate and brittle lining of the vessel would give way under the pressure of the blood.

Fig. 366.



Internal coat divided, external one unbroken.

Treatment.—In general it may be observed that in all wounds attended with much hemorrhage, the first duty of the surgeon is to arrest the loss of blood by applying, when feasible, a tourniquet to the limb, or by introducing a finger or a compress into the opening; the second is to determine its source, whether arterial or venous, and whether from a principal trunk or from one of its branches; the third, to apply a ligature to the vessel at the seat of injury. The blood from an artery issues in jets, is of a scarlet color, and is controlled by pressure on the cardiac side; while that from a vein wells up, has a blue or a purple color, and is arrested by pressure on the distal side. The following considerations will aid the surgeon in ascertaining the identity of the bleeding vessel. When the hemorrhage is from a main trunk it will be more persistent than when from a branch; pressure made at different situations will reveal the true vessel by controlling the bleeding at one point rather than at another; and if a vessel like the axillary, the brachial, or the femoral be torn, the pulse will cease at the wrist or at the ankle. An artery should not be tied near an important branch without including the latter in a ligature. To neglect this precaution is to expose the patient to the risk of secondary hemorrhage, in consequence of the uncertainty attending the formation of a permanent clot.

In complete lacerations there will be little bleeding, in consequence of the

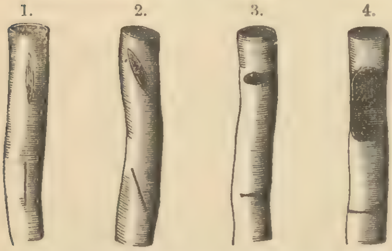
paralysis of the torn vessel and the manner in which its tattered tunics are turned in so as to blockade the orifice of the artery and give support to the internal clot. Vessels of the size of the axillary, and even of the carotid, may be entirely severed and yet only a few drops of blood escape. While this is true, it would be a fatal neglect to trust in such a case to the operation of natural processes alone. If left to itself, in a short time, when the paralysis begins to disappear or the shock which the patient has sustained has passed off, the force of the blood-stream will dislodge the coagulum, and hemorrhage will follow; or, should this not take place, the subsequent sloughing of the shattered coats will most probably open the vessel. In all cases, then, of complete laceration of an artery, both ends of the trunk should be tied, observing to place the ligature sufficiently distant from the seat of the injury to include a sound portion of the vessel.

Nor is this rule less imperative in the two forms of incomplete laceration, in both of which the artery must be tied above and below the point of damage, whenever that can be ascertained, thereby preventing the formation of aneurism or a destructive hemorrhage.

Incised Wounds.—These may be complete or incomplete. In the first the vessel is cut entirely across, and the injury is followed by retraction and contraction of the divided ends, by a gush of blood, and by the formation of a coagulum as described under the head of hemorrhage. The second or incomplete division may take place in various ways. It may be a mere nick, not extending through all the tunics of the vessel, or it may be longitudinal, oblique, transverse, and sometimes horizontal, cutting out an ovoidal portion of the tube entire. Whatever the direction or the size of these wounds, there will be more or less retraction or gaping, this, however, always being greatest in such of the tubes as are transverse, in consequence of the direction of the elastic component. This is well illustrated in Fig. 367. The subsequent phenomenon of coagulation of the blood without and between the walls of the wounded trunk does not materially differ from that which follows its complete division. These wounds are not only more troublesome than those extending through the entire circumference of the artery, but they are also more certain to be succeeded by secondary hemorrhage, as the retraction and contraction affect only a limited portion of the vascular tube, and that imperfectly, so that the resulting clot, being on the side of the artery, is constantly disturbed by the passing stream of blood.

FIG. 367.

1. 2. 3. 4.



1, longitudinal slit below, the consequent gaping seen above; 2, oblique slit, and in consequence a more extensive retraction of the wound; 3, transverse slit, exhibiting the greatest degree of gaping; 4, the effect of cutting out longitudinally a portion of the cylinder.

TREATMENT.—As in lacerated wounds, so in those which are incised, both extremities of the divided artery will require ligation. The distal extremity, owing to the collateral circulation, is as likely to bleed as the proximal. The blood when coming from the former wells up, instead of issuing in jets as it does from the latter. The same practice must be extended to incomplete or partial wounds, however slight, even when they do not penetrate the cavity of the vessel. The old practice of cutting the artery between the ligatures, as performed by Abernethy, has been long since abandoned as useless, if not dangerous, by predisposing to secondary bleeding. In wounds of a superficial vessel, an acupressure-pin above and below the lesion may be employed in an emergency.

Punctured wounds demand the same treatment as those belonging to the other classes. Shot injuries of the vessels have been treated of under the head of gunshot wounds.

Arteritis.—The arteries possess a wonderful power to resist disease, and hence they are found surrounded by purulent accumulations and by malignant growths, or lying in the midst of sloughing tissues, or even stretching across chasms formed by destructive ulceration, and yet still capable of carrying blood to the parts to which they are distributed. Idiopathic inflammation of these vessels is, therefore, an unusual occurrence, and, when it does arise, is traceable to some constitutional vice in the blood, such as exists in syphilis, gout, and rheumatism. As a traumatic result arteritis is very common, being present in every case of ligature or wound. The order of frequency in which the tunics of the vessel are involved by inflammatory changes is determined by the exciting cause. When arising from internal or idiopathic conditions, the tunica intima is first affected, and from this the disease travels outwards, extending to the middle and the external coat, and even to the loose cellular tissue about the vessel. If the arteritis has a traumatic origin, the inflammation will advance in the opposite direction, that is, from the outer to the inner coat. The earliest evidence of the external form of the disease, that most commonly encountered by the surgeon, is hyperæmia of the nutrient vessels of the cellular tunic of the artery and its sheath followed by a fibrinous and cell transudation. Should the inflammatory distention of the capillaries continue, a similar infiltration will extend to the middle coat, the effect of which will be to involve the tunica intima, producing endo-arteritis. Partly from the swelling and partly from the spasm of the muscular walls of the vessel excited under irritation of the vascular nerves and thereby diminishing the canal of the artery, the inner coat is thrown into plications, and its nutrition seriously disturbed. The walls of the vessel thus filled with the products of the inflammation may undergo several important structural alterations.

Results of arteritis.—The most common results are a new formation of connective tissue, suppuration, atheroma, calcification, thrombosis, and aneurism. These transformations may be considered to be the result of a chronic inflammation. The organization of the cell transudation, and the proliferation of the staple elements of the parts into connective tissue, may take place in the sheath, or in the fibrous or muscular layers of the vessel. When in the sheath, it may produce a sclerosis or thickening around the artery, and its adhesion to the surrounding parts. When hyperplasia of the connective tissue occurs in the external and middle tunics, it causes a corresponding wasting of the muscular and elastic components of the last-named coat, in consequence of which the vessel is rendered less able to resist the pressure of the blood; dilatation follows, frequently terminating in aneurism.

Another effect of arteritis is the formation of clots within the canal of the affected vessel, probably due to some subtle change in the vital characteristics of the intima. These clots are sometimes regarded as standing to the inflammatory phenomena in the relation of cause and not of effect. The obstructions which such coagula form may be partial or complete. The clots are frequently conical, resembling the thrombi which form after the ligation of an artery. The final disposition of these clots is not always the same: they may become organized and incorporated with the walls of the vessels, completely obliterating its lumen; or they may soften down and mingle with the circulating fluid, again rendering the canal pervious; or portions may become detached and block the artery at another point, in which case, should the collateral branches prove unable to transmit the blood to the parts below, mortification will follow; or if the fragments of the thrombus are sufficiently minute, they will pass into the capillary vessels and cause numerous points of obstruction.

When the disease advances to suppuration, the pus, if in the adventitious coat, is rarely circumscribed by a limiting wall, but becomes diffused along the course of the artery. When the suppuration is in the middle coat, it may exist in the form of distinct abscesses, liable to open into the vessel and mingle their contents with the blood, causing a fatal pyæmia.

SYMPTOMS.—There are no symptoms which are so specifically characteristic of deep-seated arteritis as to enable the practitioner to detect with certainty its existence. The tension of the vessel, arising from a diminution of its canal, the empty state of its branches, the diminished temperature of the parts to which it is distributed, and the impaired movements of the limb on the affected side, are all grounds for suspecting the presence of the disease. When the inflammation is seated in arteries which are accessible to the touch, there will be less obscurity. The affected vessel will have a hard, cord-like feel, and be tender on pressure; there will be deep lancinating and radiating pains, and the entire limb will be stiff and helpless. In the commencement the disease may be mistaken for rheumatism. When obstruction is present, the pulsation of the vessel below will be diminished in force, or may be entirely suspended; and when the vitality of the parts supplied by the crippled artery is threatened, their temperature will fall, and their color become dark and mottled.

TREATMENT.—When arteritis arises from idiopathic causes, as rheumatism or gout, the best remedies will be the iodide of potash with colchicum and belladonna. If the patient is strong and vigorous, or if the attack has been provoked by a too free indulgence in eating and drinking, these remedies must be preceded by an active purge, consisting of calomel followed by a saline cathartic. To relieve pain and to procure rest, Dover's powder will prove most serviceable. As a local application, the use of laudanum-and-water will often prove very comforting to the feelings of the patient.

Atheroma.—The term atheroma is used to express a peculiar degeneration of the arteries. Though no vessel can be said to be exempt from the disease, yet it is most commonly seen in the arch of the aorta, and in the iliac, tibial, cerebral, coronary, brachial, radial, and ulnar arteries. Males appear to be oftener affected with this degeneration than are females. The natives of the United States are singularly exempt from this affection, as compared with our foreign population. The disease is said to be very common in Great Britain, and also in Paris.

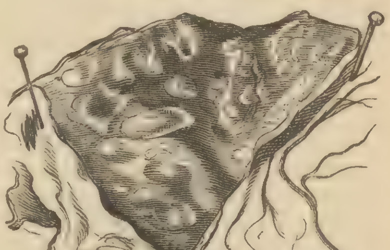
There are two varieties of atheroma, the *senile* and the *premature*. The first is rarely seen in the young, but is most commonly observed after fifty years of age. The second begins as early as thirty, is generally the result of alcoholism, and is much more common than is generally supposed. In cases of extensive atheroma it is not unusual to find the corresponding vessels of the two sides suffering alike. Veins are seldom affected with atheroma. There are three stages,—infiltration, fatty degeneration, and calcification.

Anatomical characteristics.—The disease generally commences in the internal coat of the artery, and in the deepest or the most external lamellæ of this coat. These layers become thickened, to accommodate which change the innermost part of the intima is pressed in the direction of least resistance, that is, inwards towards the canal of the vessel, causing numerous flat projections of various sizes and of irregular outlines. These thickenings are caused by the multiplication of cell-elements in the lamella, some of which originate in an active proliferation of the connective-tissue corpuscles of the part, and others, probably, are emigrants from the vasa vasorum. The effect of this infiltration is twofold: first, to sclerose or harden the tunica intima; and, second, to interfere with its nutrition, by offering a mechanical obstacle to the access of blood. The effect, therefore, of a diminished blood-supply is to inaugurate a retrograde metamorphosis of both the new and the old elements. Their cell-contents become changed into fatty materials, and this constitutes the commencement of the second stage. To the eye the vessel now presents numerous spots or streaks of a yellow or light-gray color, which in time become confluent, forming patches of considerable size, and which have a greasy feel. While this degeneration is in progress in the external layers of the intima, cell infiltration goes on in the more internal ones. Not only does this fatty transformation invade the cells, but it also induces

changes in the intercellular substance of the connective tissue, the softening down or the liquefaction of which—intermingled with fat-globules, granules, and fragmentary particles of disorganized lamellæ—constitutes a soft, pulpy mixture, which has been called the atheromatous abscess. As the disease advances, one lamina after another of the internal coat yields to the transudation, the fatty transformation at the same time following closely on the infiltration, until there may remain only the most delicately attenuated film of the intima between the blood and the soft atheromatous substance beneath. This film frequently becomes fissured, and allows the purulent-looking accumulation to escape into the vessel and to become intermixed with the blood. The opening which remains, and which extends between the intima and the middle coat of the artery, often in a very irregular, sinuous manner, forms the so-called *atheromatous ulcer.* The effect of the swelling of the tunica intima, from the presence of plastic matter and of cell-forms, is to encroach upon and diminish the lumen of the vessel. This swelling has been improperly interpreted by certain writers, who have supposed that this diminution in the canal was caused not by transudation in and beneath the layers of the internal coat, but by a deposition upon its inner surface.

The effect of the above changes is to modify seriously the physical properties of the arterial tube. It loses much of its elasticity, is deficient in firmness of texture, becomes soft, dilating unequally, and is easily lacerable. Though it is true that the internal coat usually takes precedence in atheromatous change, yet the disease is by no means limited to this part of the vessel. The middle or muscular layer participates in a similar metamorphosis. The order of the phenomena in such an event corresponds to that described as occurring in the intima. Cell-forms appear between the inner and the middle coat, and interpenetrate the fibres of the muscular layer; the sarcous contents of the muscle-cells are replaced by fat, forming greasy, yellowish, circular streaks about the vessel, which eventually constitute the same kind of creamy pulp as that in the atheromatous abscess already described. With such alterations in the nutritive processes of an artery, it would be singular if its external or fibrous coat should escape being involved in the disease. Accordingly, we find that a period is reached when the tunic becomes red and swollen with transudation, and its fibres swarm with migrated leucocytes and with other cells which arise by an active proliferation of its stable connective-tissue corpuscles. Many of these forms are developed into connective or cicatricial tissue, white in color, hard and inelastic in its constitution, and which, with the wasted elements of the middle coat, may become blended with the remains of the intima.

Fig. 368.



Arch of the aorta laid open, exhibiting an aggregation of calcified plates.

Calcification.—The degenerative stage, which next appears, is that of calcification; that is, the deposit of lime-salts in the fibrous and other remaining components of the vessel. This deposition is by no means uniform. It may occur in irregularly-disseminated grains, giving a rough, granular appearance to the vessel; it may form in scales, rendering the artery rigid and inelastic,—a condition common to the aorta and other large trunks; it may appear as thin, elongated plates, with irregular borders, and separated from adjoining ones by fat-globules, so as to give a pavement-like appearance to the surface of the artery (Fig. 368); or these plates may increase in thickness and in extent until the tube becomes converted into a hard cylinder. Another singular disposition of these salts is an annular aggregation of grains, which follow the

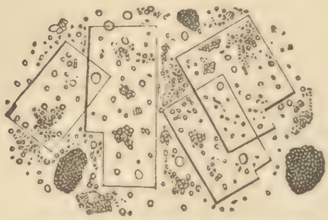
circular disposition of the muscular fibres of the media, giving an appearance to the artery not unlike that of the trachea. These calcified rings may become united by intermediate deposits until the tube is transformed into a canal of almost stony hardness. The femoral, popliteal, tibial, radial, and ulnar arteries furnish the most common examples of this condition. (Fig. 369.)

Microscopic appearances.—A microscopic examination of an atheromatous artery reveals the existence of oil-globules, small scales having a white, shining appearance, fragments of earthy matter, numerous minute particles, crystals of cholesterin, and leucocytes, together with the proximate constituents of fat,—oleine, margarine, and stearine. These components are found mixed with other tissue-débris of the affected artery. (Fig. 370.) The earthy deposition, when carefully examined, exhibits neither bone-cells nor that orderly arrangement of parts which forms the Haversian system found in true osseous substance, and therefore cannot properly be termed a process of ossification.

Fig. 369.

The brachial artery, and part of the radial and ulnar arteries, converted into rigid, calcified tubes. The annular arrangement of the grains of lime-salts is seen where the interior of the vessel is exposed.

Fig. 370.



Microscopic appearance of arterial atheroma.

Causes.—We have seen that atheroma is essentially a fatty and a calcareous degeneration of the walls of a vessel. There are two views entertained by writers on the nature of this arterial degeneration. Moxon* believes that it originates in inflammation, and that the inflammation is induced by vascular tension. In support of his opinion this writer states that those diseases which tend to diminish such tension, as phthisis and mitral insufficiency, are rarely attended by atheroma. Niemeyer† and Virchow‡ both believe in the inflammatory doctrine. Holmes§ regards strain or overstretching of the arterial walls as principally concerned in producing the disease. Gulliver‖ adopts the non-inflammatory view, holding that the inner coat is primarily affected, and that the stenosis of the arterial canal is to be attributed to a deposit from the blood upon the intima, without any previous infiltration of the other coats. This view would transfer the essence of the disease from the tunics of the vessel to the blood. The fact that atheromatous change is in almost all instances met with in the arterial system of vessels would seem to connect it in some way with arterial blood, and therefore to favor the idea of a primary deposition from that fluid; but, on the other hand, the alteration being frequently seen to occur in patches, and not generally affecting extensive portions of a vessel, would militate against this doctrine. It has been stated by some writers, who are adverse to this opinion, that the disease is not confined to the arteries alone, but occasionally invades vessels carrying venous blood, and one—the pulmonary artery—in which the blood is intensely venous. I am unable, however, to find more than a single recorded case of this kind,—one reported by Dr. Gerald Yeo:¶ in this the pulmonary artery and all its branches were atheromatous, caused, it was supposed, by a constriction which existed at the mitral opening, and by hypertrophy of the right ventricle. If such were the proper explanation, it would tend to confirm the doctrine of Holmes,

* Guy's Hospital Reports, vol. xvi., third series, p. 431, 1871.
† Text-Book of Practical Medicine, vol. i. p. 345. ‡ Cellular Pathology.
§ System of Surgery, vol. iii. p. 396. ‖ Medico-Chirurgical Trans., vol. xxvi. p. 86.
¶ Transactions of the Pathological Society of Dublin, vol. v. part ii. p. 123.

namely, arterial tension. Too much weight, however, must not be attached to exceptional cases in the investigation of pathological questions. The most probable view, in my judgment, is that the disease is in all cases inflammatory in its origin, that the predisposing causes may be either alterations in the constitution of the blood or arterial strain, and that the deposit which takes place in the layers of the tunica intima is due to the altered nutrition of that membrane from the interpenetration of its laminæ by migrated leucocytes and from the proliferation of its normal cell-elements. The effect of chronic inflammation in determining fatty degeneration of tissues in other parts of the body, even in non-vascular structures like the cornea and cartilage, is well known; and I can discover no reason why similar degenerations occurring in the arteries should require a different explanation. Gout and rheumatism are regarded as being active in the production of atheroma. Syphilis is also deemed a fruitful source of the disease. With reference to the last-named affection, Moxon asserts that it exercises no influence whatever in causing these changes, though I think there can be no doubt that syphilitic blood, remotely at least, has much to do with arterial degeneration.

Alcohol, in my judgment, is more actively concerned than all other causes combined in bringing about atheroma, especially of the variety which I have termed "premature."

Nor must we overlook the effect of those changes which are incident to advanced life, changes which notably lower the life-forces of the body, and, of course, the functional activity of the different organs. The muscles grow less supple, the ligaments stiff and inelastic, the cartilages of the ribs and the larynx ossify, and the heart-muscles become enfeebled by fatty transformation. All these phenomena, which belong to the decline of life, would appear to invest the changes attending senility with paramount importance as a favoring cause of arterial atheroma.

Symptoms.—There are no symptoms which enable the practitioner with any certainty to detect atheromatous transformation in vessels, unless the change has advanced to calcification and the artery is accessible to the touch, when the rigid, irregular, and granular surface of its walls will sufficiently declare the existence of such a change. If, however, a man has passed his fiftieth year, or has been the subject of gout, of rheumatism, or of syphilis; if the pulse becomes a little irregular in its action and the respiration is quickened on his taking the usual exercise, without any abnormal sounds of the heart being present other than, perhaps, a slight murmur, and without there being any physical alteration in the pulmonary organs to explain the defect in breathing; and if, in addition to these symptoms, the fatty ring (arcus senilis) is seen at the circumference of the cornea, the existence of atheromatous change in the aorta and other vessels near the heart may be deemed highly probable.

Treatment.—There are no remedies with which we are acquainted that are capable of removing the transformation under consideration. The solvent action of lactic acid upon the lime-salts would suggest the free use of milk as an article of diet, not with the hope of removing calcification when once established, but to favor a constitution of the blood which should be, in some degree at least, incompatible with its existence. Much may be done, however, in this way of palliation by attending to the condition of the kidneys and digestive organs, at the same time directing the patient to lead a quiet life and avoid every cause calculated to quicken the action of the heart and to increase arterial tension.

Consequences of Atheroma.—*Thrombosis*, or obstruction of an atheromatous artery by the formation of a clot, is frequently induced by the grains, scales, or plates of calcified matter projecting into the lumen of the vessel, and offering those irregularities which, by contact with the blood-stream, favor coagulation. This is a common cause of cerebral embolism.

When the arteries of an extremity become obstructed, the condition is announced by pain, loss of heat, numbness, and stiffness of the limb. The skin becomes mottled, and finally dark and gangrenous. When the obstruction grows slowly, the collateral vessels may be able to supply the parts below with blood; but when the thrombus is quickly formed, the danger of mortification is imminent.

Ulceration.—The rupture of the intima and the escape of a portion of softened atheroma into the vessel, leaving an irregular excavation in its walls, the circumference of which becomes thickened by a formation of organized transudation, constitute what has been termed an ulcer; but there is a form of ulceration which destroys all the coats of the artery, opens externally, and is followed by hemorrhage. I lost a patient from this cause by an ulcer perforating the common iliac a short distance above where a ligature had been applied on account of secondary hemorrhage after ligature of the external iliac for aneurism. I am not prepared to say in which part of the vessel, in this case, the ulceration began, whether the external or the internal, though it is believed that in true ulceration of arteries the external tunic is first attacked by the inflammation.

Dilatation.—When a portion of the internal coat of an artery is destroyed by atheromatous degeneration, the blood finds its way through the opening, and, by pushing off the fibrous from the muscular tunic, forms the *dissecting aneurism;* or, instead of separating the tunics in this manner, the middle and external coats may yield over a limited part of the vessel, giving rise to a diverticulum, or pouch-like protrusion of its walls, presenting the ordinary appearance of a true aneurism. The pouch may become so thinned by the pressure of the blood as finally to give way and destroy the patient by hemorrhage.

Hypertrophy of the left ventricle, and arterial dilatation.—The change which takes place in the physical and vital properties of a calcified artery is such as to act both upon the centre of the circulation and upon its peripheral extensions. When an artery is sound, and the blood is driven into its canal by the contraction of the left ventricle, it first expands by virtue of the elasticity of its middle coat, and then contracts upon its contents by the reaction of the muscular and elastic layers. The propulsive power of the heart is thus supplemented, and the stream rapidly hurried forward. When, however, these vessels are changed into rigid, unyielding tubes, their walls offer a direct resistance to the force of the heart, and thereby slow the blood-current. Such an obstacle compels the heart to exert a more vigorous stroke, and diverts a larger amount of blood into those vascular trunks which remain sound. The effect is to induce hypertrophy of the left ventricle, and dilatation of the vessels unaffected by the disease.

Loss of temperature.—When the smaller ramifications of the greater circulation are calcified, for example, those of the lower extremity, the retarded flow of the blood and its defective distribution diminish the activity of tissue-change, and as a consequence lessen the evolution of heat. From this cause persons who are the subjects of this degeneration will frequently complain of cold feet.

Cramps.—The spasmodic contractions of the muscles of the legs, so commonly complained of by aged persons, are to be attributed to the altered condition of the blood from its tardy circulation, rendering it unfit for the demands of the nerve-centres, and thus causing these displays of irregular nerve-action.

Mortification.—The obstruction offered to the circulation by coagula, which form so readily in calcified vessels, or the sluggish movement of the blood through its rigid channels, may so starve the districts to which the diseased vessels are distributed as to induce their mortification. Senile and other forms of gangrene are illustrations of this condition.

TREATMENT.—Little can be done in the way of treatment for the relief of the complications arising from atheromatous degenerations. Everything

calculated to stimulate the heart should be avoided, the patient leading a quiet life, free from all excitement. When the temperature becomes lowered and the extremities suffer from cold, often the precursors of mortification, external warmth and stimulating frictions must be applied, in order to favor the circulation of the blood. Opiates should not be withheld when pain and restlessness are present. For the cramps in the legs which so often harass aged persons suffering from calcified arteries, nothing affords more prompt relief than dry heat applied to the parts.

When mortification follows, the fetor must be corrected by deodorizing agents, such as charcoal and fermenting poultices, or by solutions of permanganate of potash, bromine, or carbolic acid. The general strength will require to be supported by nutritious food, tonics, and stimulants, and all pain must be relieved by anodynes. Few persons survive the disease, death taking place during the progress of the mortification. In rare instances, where the arterial obstruction has been quickly formed, and the death of the part rapid, a line of demarkation has been established, and the limb successfully removed.

Amyloid Degeneration.—This obscure affection is most commonly observed in the smallest arteries, especially in those distributed to the elementary parts of large secreting organs like the kidney and the liver. When found in large vessels, it is in those very closely related to the heart, as the aorta, carotid, and innominate pulmonary arteries. It is regarded as an infiltration, entering both the cells and the non-cellular components of a structure, and imparting to these a swollen, distorted, shining, and vitreous appearance. In chemical constitution the amyloid formation is an albuminate, but it behaves under certain reagents in a manner different from ordinary albumen. The addition of iodine produces, with this peculiar substance, a brownish-red color. Like fibrin, the material does not normally exist in the blood, but is the product of certain subtle changes which take place during transudation, as has been stated by Friedrich, between the albuminous matters of the blood and the tissues through which these matters pass. The deposit affects both the inner and the middle coat of an artery, and has been seen in the fibrous tunic, extending even to the connective tissue beyond the vessel, transforming these tunics into white, glassy-looking particles. The swelling resulting from the infiltrate encroaches on the canal of the vessel, much as in atheroma, and in small arterioles may ultimately occlude their channels. The amyloid degeneration is induced by protracted suppuration, and by syphilitic and other causes, which slowly induce those alterations of the blood and tissues which establish what we are wont to term a diathesis, or a dyscrasia.

Aneurism.

An aneurism is a tumor which contains blood, and which communicates directly with an artery. Fernelius* was the first to ascertain the proper relation of aneurismal tumors to the arteries.

Division.—Aneurisms are divided, first, into *internal* and *external*:—internal, when situated within the great cavities of the body; external, when located upon the vessels of the head, neck, and extremities. To the former division belong aneurism of the cerebral arteries, aneurism of the aorta, of the iliacs, and of the mesenteric arteries.

A second division is into *spontaneous* and *traumatic*, according as they arise without or with a visible injury.

A third division is into *true* and *false* aneurism:—true, when the blood is contained in a sac formed by one or more of the coats of the affected vessel, and false, when it escapes from the artery into the surrounding tissues, either in consequence of a wound in the vessel or from rupture of an aneurismal sac. In the last instance we have an explanation of the manner in which a

* Universa Medicina de Ext. Corp. Affect., lib. vii. cap. 3, Venet., 1564.

true may be converted into a false aneurism. Another variety under the false division, so placed by Broca and others, is *dissecting* aneurism.

A fourth division is that of *arterio-venous aneurism*, under which are two varieties, the *direct* or aneurismal varix, and the *intermediate* or varicose aneurism.

Breschet,* in addition to the varieties named, makes two others, namely, *aneurism by anastomosis*, so called by John Bell, and *cirsoid aneurism*. These two, so entirely different in their anatomy from aneurism, I have treated under the head of angeiomatous growths. Hunter believed in a *hernial aneurism*,—that is, one in which, the external and middle coats of a vessel being torn or divided, the internal one, or the intima, pressed through the opening thus made and formed a tumor. Dr. Crisp refers to such a specimen in the Museum of the London College of Physicians. Mr. Erichsen, however, after having examined this specimen, came to the conclusion that the external coat of the aneurism had been dissected off. I am not aware that a single example of this form of the disease, verified by dissection, exists in any pathological cabinet.

Fig. 371.

Fusiform aneurism, with layers of fibrin and canal for the blood in the centre.—After Hodgson.

True aneurism may arise spontaneously or from traumatic causes. It consists in a dilatation or a stretching of one or more of the coats of an artery. When this stretching is uniform in all directions, that is, in the entire circumference of the vessel, it is called a *fusiform* or spindle-formed aneurism. (Fig. 371). When the dilatation takes place from a small portion of the artery and projects from its surface like a bud, it constitutes the *sacciform* or sacculated aneurism.

The fusiform aneurism is not a common variety of the disease, and is generally restricted to a few vessels, like the aorta, carotid, and iliac. In the commencement of the aneurism the sac probably possesses all the tunics of the artery, a circumstance which in a measure explains the peculiar shape of the swelling. In addition, the walls are greatly thickened either by an unusual nutrition or by inflammatory formations of connective tissue, imparting such a degree of strength to the sac that it rarely becomes ruptured. The rapidity with which the blood passes through a channel so direct as that of a fusiform aneurism proves unfavorable to the formation of stratified fibrin or of blood-clots, and hence these deposits are usually absent in this form of the disease. When the inner surface of the sac becomes rough and convoluted,—a not uncommon condition,—both coagula and fibrinous laminæ may form. Figure 371 is an illustration of the presence of such formations. As a fusiform aneurism may form independent of any atheromatous change, it is highly probable that it is a product of arteritis. At all events, it is certain that inflammation plays a conspicuous part in the progress of this variety.

Sacculated aneurism is much the most common form of the disease. It begins by a projection from the side of the affected artery, which gradually enlarges, until a tumor of great magnitude may be formed. (Fig. 372.)

The aneurismal sac.—The formation of the sac is generally a gradual process. First, at some point where the artery, in consequence of structural

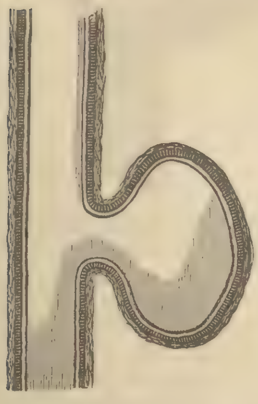
* Sur différentes Espèces d'Anévrismes.

change, is unable to resist the pressure of the blood, the coats begin to yield, forming on the side of the vessel a little prominence or bud-like dilatation. This will continue to enlarge, the resistance of the arterial tissues diminishing as the tumor increases in size. During the period of enlargement the coats of the vessel, which form the walls of the aneurism, undergo important changes. They may continue for some time to retain their continuity and, in a measure, their distinctive characteristics, all three forming a constituent of the sac. When this is the case the intima will generally be found thickened by chronic inflammation, and maintaining an unbroken structure, even when the sac is of considerable size. At the same time that this inflammatory hyperplasia is going forward, a retrograde process is also in operation, converting this coat into plates of lime, the projection of which on the inner surface of the sac may have considerable influence in causing the formation of thrombi. The middle coat appears to be the most powerless to withstand the dilatation. Its muscular constituents separate into small circular sections, and as these become stretched and attenuated they rapidly undergo fatty metamorphosis and, in a great measure, disappear (Fig. 373); or the internal coat may give way, the middle and external ones remaining (Fig. 374);

FIG. 372.

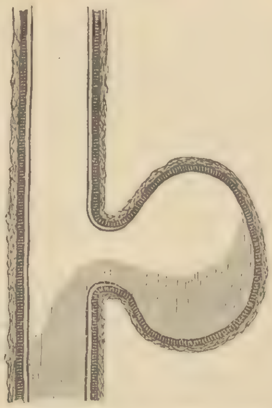
Sacculated aneurism of the arch of the aorta.

FIG. 373.



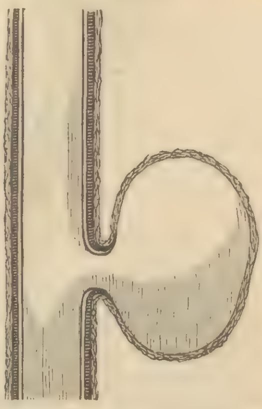
Aneurismal sac consisting of the three tunics of the artery.

FIG. 374.



Sac formed of the middle and external coats of the vessel.

FIG. 375.



The internal and middle coats broken, and the external coat of the artery remaining.

and, last, the internal and middle tunics may yield, the external or fibrous coat alone preserving its integrity. (Fig. 375.) Even when all the coats remain intact it is not always possible to recognize them. They are often much changed by inflammatory infiltration, in a great measure obliterating their normal appearances; sometimes they are thickened, and at other times wasted; sometimes they are hypertrophied at one point and atrophied at another; and not unfrequently all three of the tunics are agglutinated together into one layer, in which the characteristics of the separate coats become indistinguishable. In most cases of sacculated aneurism which have attained any considerable size, the external or fibrous layer of the artery alone forms the wall of the sac. This coat, however, is generally altered from its normal state by the inflammatory changes to which it has been subjected during the progress of the disease. It may acquire great thickness and density, or it may be thinned out until it is no longer able to resist the force of the

circulation, when it gives way (Fig. 376), destroying the patient in a few moments from hemorrhage. The sac may reinforce itself by becoming united to contiguous parts, and remain in this way unchanged for a long time. In some instances the sac has ruptured and its contents have been discharged into the surrounding tissues, out of which a second sac is sometimes constructed. (Fig. 377.) This occurrence is a wonderful illustration of the amazing resources possessed by the body to provide for extraordinary emergencies.

FIG. 376.

Aneurismal sac which has burst.

FIG. 377.

Rupture of the sac of aneurism, and the formation of a second out of the condensed tissues around the extravasated blood.

The size of an aneurismal sac will vary. It may not be larger than a pea, and it may attain the size of the fœtal head. I have seen an aneurism of the abdominal artery equal in volume to the uterus at full period. There is a man, well known to the profession of Philadelphia on account of the frequent assessments which he makes on their benevolence, who, in consequence of an aneurism of the abdominal aorta, is obliged to incline his body very much to one side in order to counteract the weight and protrusion of the other from the unusual size of the tumor.

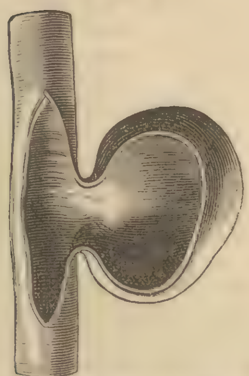
Form of the sac.—In the variety of aneurism under consideration the sac may be spherical, oblong, or pyriform. Its walls, not being of equal thickness or strength, may yield more at one point than at another, giving to its surface a multilocular appearance. The expansion of the sac from the point where it is immediately connected with the artery, often renders the aneurism pedunculated, whatever may be the form of its body. (Fig. 378.) When the aneurism springs from the arch of the aorta it is frequently fusiform in shape, and may develop downwards (Fig. 379), or in a direction opposite to that in which the vessel sustains the greatest strain from the force of the blood. Occasionally the aorta rises into a pyramidal sac, its branches participating in the dilatation.

Opening into the sac.—The communication between the artery and the sac is sometimes small, and at other times large; it may be round or oval, and generally the boundaries of the opening are smooth. The internal and middle

coats may terminate abruptly at the orifice, or they may be continued a little way into the sac.

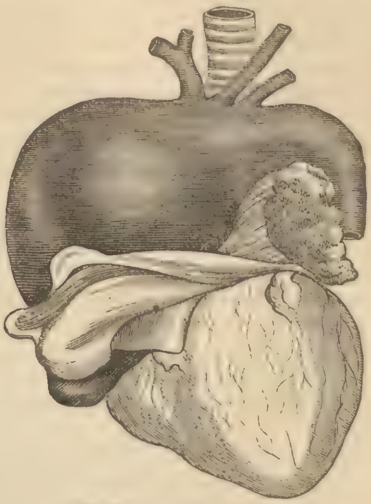
Contents of sac.—When the sac is spindle-shaped or fusiform, appearing as a cylindroid dilatation of the vessel, the blood generally rushes through

FIG. 378.



Popliteal sacciform aneurism, having a pedunculated attachment to the vessel.

FIG. 379.



Fusiform aneurism of the aorta.

in a direct current unchanged; but in the sacciform aneurism the circulation is impeded, the blood moves with diminished rapidity, and as indentations in the banks of a stream cause eddies or reflux currents, so a diverticulum or an expansion from the side of an arterial trunk causes very much the same disturbed movements in the circulatory blood. The effect of such obstruction is to induce a laminated deposition of fibrin, the first layer being placed against the inner surface of the sac, and other layers successively inwards (Fig. 380), until, in favorable cases, the sac may become filled with concentric stratifications of this substance and the aneurism undergo a spontaneous cure. These layers of fibrin are pale, or have a light buff color, are very elastic, and are almost leathery in their consistence. Those laminæ which lie nearest to the inner surface of the sac are thoroughly decolorized, whilst those more internal, and of course of more recent formation, are blood-stained and comparatively soft. In addition to the decolorized clots, others having a red, soft look lie within the last, and have been not inaptly compared in appearance to currant jelly. Broca imputed to this fibrinous concretion important vital properties. By this author it was called "active clot." Some of the older writers believed that the layers of the fibrinous clot were derived from the blood-vessels of the inner surface of the sac, and not from the blood moving through its interior. That such coagula are susceptible of organization I entertain no doubt. There are strong reasons for believing that the cure of an aneurism and the obliteration of its sac are effected very much in the same manner as a vessel is closed after ligature,—that is, by thrombosis, the development of the white corpuscles of the clot into connective tissue, the construction of blood-channels, and, after this, a free intercommunication of these channels with the vessels in the walls of the sac, the whole being eventually converted into a dense cord of connective tissue. As the process of fibrinous deposition commences early in an aneurism, it is doubt-

FIG. 380.

Concentric deposition of the layers of fibrin in an aneurism which has been laid open.

less designed to strengthen the sac, and to indicate the plan pursued by nature to effect a spontaneous cure. It is easy to understand how much the force of the heart-stroke, exerted against the inner surface of the sac, will be neutralized by the interposition of an elastic substance like these stratifications of fibrin. The effect may be compared to that of buffers placed between the bumpers of cars. Aneurisms which are deficient in such laminæ, either in consequence of their unusual form or from some peculiar constitution of the blood unfavorable to coagulation, increase rapidly in size. A fragment of blood or fibrinous clot is liable to become detached and to be washed from the sac into the vessel below, where it may cause an obstruction to the circulation so complete as to result in mortification. I treated a patient during the winter of 1875 for popliteal aneurism. After pressure of the femoral had been maintained for twenty-four hours, all pulsation ceased in the tumor, and the man was regarded as cured. On the following day a person who had received a severe railroad injury was brought into the ward and placed in an adjoining bed to that occupied by the individual with aneurism. The sight of the mutilated limb had such an effect on the mind of the latter that he commenced vomiting and tossing about on his bed. A few hours later, pulsation was again observed in the tumor, the temperature of the foot began to fall, and in a short time mortification commenced. This case was an illustration of a detachment of some portion of the clot which had formed during compression, and its subsequent blocking up of one or both tibial arteries.

Effect on adjoining structures.—As an aneurismal sac enlarges it becomes united by inflammatory transudations to the soft parts with which it may come in contact. Such adhesions render a timely service to the aneurism, by retarding the enlargement of the sac, and rendering its rupture less probable. In all other respects, however, the pressure caused by a growing aneurism is followed by serious consequences. When the tumor encroaches upon large veins it will give rise to congestion and to œdema in the part drained by their trunks. Thus, an aneurism of the carotid may cause dangerous cerebral symptoms, from over-distention of the intracranial veins and sinuses; and in the same manner does the cellular tissue of the arm or of the leg become œdematous when an aneurism of the subclavian or of the femoral obstructs the flow of blood through the axillary or the crural veins. If the pressure is continued for any length of time, the cavity of the vein becomes closed by inflammatory adhesion of its walls. When the pressure is exerted against a nerve it will cause severe neuralgic suffering, and in some instances produce loss of power in, or spasmodic disturbance of, the parts supplied by its branches. In aneurism affecting the arteries at the root of the neck, we frequently have hiccough and irregularities in the movements of the diaphragm, from pressure on the phrenic nerve, and also a sense of suffocation from spasm of the glottis, due to like compression of the recurrent laryngeal. Dyspnœa may result in another and still more distressing way, by the tumor encroaching upon the trachea and obstructing the passage of air into the lungs. The thoracic duct is sometimes implicated in the enlargement of the tumor, by which the lymph-stream is interrupted, followed by rapid emaciation. The sac may contract adhesions to important organs, and by ulceration open into their cavities, causing instant death. Thus, an aneurism may open into the trachea, the œsophagus, or the pericardium, or occasionally into the heart or into a large vein. R. A. Jamieson* records a case of popliteal aneurism which opened into the knee-joint. Amputation of the thigh was performed, but the patient died the following day. I once examined the body of a man who died from a long-continued, but not a severe, hemorrhage, as was thought, from the lungs, though the most careful examination revealed no lesion in these or in any other organs. After a very diligent search through all the cavities of the body for an explanation of his death, it was finally discovered in the existence of a small aneurism of the thoracic aorta, not larger than a

* Lancet, 1871, vol. i. p. 851.

hickory-nut, which had become united to the œsophagus and through an extremely small ulcerated opening poured its blood into that tube. Even the bones are powerless to resist the incessant hammering to which they are subjected by contact with an aneurismal sac. Portions of the vertebræ gradually disappear by absorption, leaving irregular gnawed excavations in the spinal column; the sternum and the ribs undergo similar changes. Very recently I saw a patient suffering from aneurism of the aorta, before which a portion of these bones had disappeared, and the tumor had passed through the opening and lay directly under the integument over the front of the chest. It is rare to find any purulent matter at these points of ulcerative absorption, a fact long since observed by William Hunter.* The structures which longest defy the encroachments of an aneurism are the cartilages, and it is not uncommon to see the bodies of the vertebræ extensively destroyed while the intervertebral disks still stand amid the surrounding ruin. In addition to the above changes, remarkable displacements of surrounding parts are frequently found associated with enlargement of the sac. Thus, in aneurism of the subclavian and of the axillary, the shoulder may be thrown upwards, or the scapula project very much from the body; and in post-orbital aneurism, the eye will become preternaturally prominent.

Aneurism is more common on the right side than on the left. In the tables of Norris on the "Ligation of Arteries for Aneurism and for Hemorrhage,"† there are tabulated 260 cases of true aneurism, 143 of which were on the right side and 117 on the left. The greatest disparity was found in aneurisms of the carotid artery, 33 in number, of which 21 were on the right side, 8 on the left side, and in 4 the side is not stated. The nearest approach to an equal number on the two sides was found in 126 popliteal aneurisms, 62 being on the right, 60 on the left, and 4 not stated. In examining the list of aneurisms collected by Hunter I found the same result. In 16 cases of carotid aneurism, 7 were on the right and 1 on the left side, and in 8 the side was not mentioned; and of 143 popliteal aneurisms, 41 were on the right side, 43 on the left, and 59 not stated.

Number and duration.—It is not common to meet with more than a single aneurism in the same person. Occasionally the disease is seen affecting both popliteal arteries. Sir Astley Cooper found seven aneurisms in the body of a man; Tyrrel saw eight in the same person; and Pelletan counted sixty-three.‡

The duration of aneurism varies in different persons. In the young, who possess an energetic circulation, its course is usually rapid; but in persons somewhat advanced in years, and who lead a quiet life, the disease may not terminate for three or four years.

Causes of Aneurism.—The causes of aneurism are predisposing and exciting.

Predisposing causes.—Considering the beautiful combination of muscular, elastic, and fibrous materials constituting the walls of the arterial system, it is extremely improbable that, without some important antecedent structural change, they should ever become the subjects of aneurismal dilatation.

Atheroma.—To atheromatous degeneration is credited the large proportion of spontaneous aneurisms; and it is true that we find the latter electing those vessels which are most commonly the seat of this transformation. It must not, however, be overlooked that atheroma is a change which attacks the vessels at a period of life generally beyond fifty, while aneurism prevails most frequently between thirty and forty. The particular form of atheroma which is most concerned in the production of aneurism is what I have described as the premature, and is generally caused by the excessive use of alcohol. Intemperance I believe to be the most prolific of all causes in the development of arterial degeneration.

Syphilis.—The doctrine that constitutional syphilis is a fruitful source of

* Medical Observations and Inquiries, vol. i. p. 384.
† Norris, Contributions to Surgery, p. 220.
‡ Lancet, 1864, vol. i. p. 245.

aneurism, and especially of the intra-thoracic form of the disease, has for some time been gaining strength, and may be said, at present, to be deeply rooted in the medical mind. Our knowledge of the relation between syphilitic poison and arterial degeneration is entirely too meagre to warrant any hasty generalizations on this point. The multitudinous manifestations of syphilis, when it is once intrenched within the body, are so far-reaching that many medical men are swept from the solid ground of induction into a maze of conjecture, attributing every accident and every illness to this constitutional vice. If aneurism is so commonly the sequence of a syphilitic diathesis, how shall we explain the infrequency of the former disease in females, who furnish so many examples of the latter affection? During an experience of twelve years in the Philadelphia Hospital, an institution which is exceptionally rich in syphilitic disease, I never witnessed a single case of aneurism among the inmates of the venereal department.

Age.—Aneurism is largely a disease of middle life, the greatest number of cases occurring in the decade between thirty and forty. Under twenty years of age the affection is very unusual; and the same may be said of cases appearing after sixty. The annals of surgery furnish a few examples of aneurism in the young. Syme* operated in one case of popliteal aneurism in a boy seven years of age. T. Smith† tied the external iliac in a femoral aneurism, the patient being twelve years old. The same surgeon says, "No case so young has been recorded at the Hospital for Sick Children out of 12,000 inmates for fourteen years." Sir Astley Cooper‡ mentions a case of aneurism of the anterior tibial artery in a lad eleven years of age. Instances are also recorded by Ogle, Hutchinson, Armitage, and others, in which the ages of the patients affected with aneurism varied from four to seventeen years. These, however, do not affect the general rule, viz., that the disease is one belonging peculiarly to middle life.

Lisfranc reports 120 cases, 59 of which occurred in persons between thirty and forty-five. In this list, one case of a boy thirteen years old, and 3 cases between fifteen and twenty years of age, are mentioned. After fifty the number diminished rapidly, as follows: between fifty-five and sixty, 3 cases; between sixty and seventy, 3 cases; and between seventy and eighty, 3 cases. Of 551 cases of internal aneurism collected by Crisp,§ 398 were met with in persons between thirty-five and forty years of age. Hayden‖ states that of 15 cases of aneurism of the aorta under his care, 11 were in persons between thirty and fifty. The same author furnishes a table of 84 cases of aneurism of the aorta, 56 of which were between thirty and thirty-five.

Of 246 aneurisms—not including any of the aorta—which I have analyzed, 125 appeared between thirty and forty. Only 4 of the entire number occurred under twenty years, and 19 over fifty years of age. Lebert's collection of internal aneurisms amounts to 342, the largest number of which in any one decade (80) occurred between the ages of thirty and forty; and the same is true of the 243 cases collected by Liddell, of New York.

Sex.—The influence of sex as a predisposing cause of aneurism is very remarkable. Crisp, out of 551 cases, found that less than one-eighth occurred in females. An analysis of 320 cases, made by myself, showed 269 males and 26 females; in 25 the sex was not ascertained. Lisfranc reports 154 cases of aneurism, 141 being in males and 13 in females. Hodgson, in 63 cases of aneurism of all kinds, found 56 in males and 7 in females. In a collection of 143 cases of aneurism (not including aneurism of the aorta) made by Hunter, 123 were in males, 8 in females, and in 12 the sex was not named.

In Norris's tables on the "Ligation of Arteries for Aneurism and Hemorrhage," I find 361 cases of aneurism of the subclavian, iliac, carotid, and femoral arteries, 337 of which were in males and 24 in females.

Sir Astley Cooper, in an experience of forty years, saw only eight cases of

* Edinburgh Monthly Journal, 1844.
† British Medical Journal, March, 1867, p. 280. ‡ Cooper's Lectures, vol. ii. p. 40.
§ Diseases of Blood-Vessels, p. 113. ‖ Hayden, Diseases of Heart and Aorta, vol. ii. p. 1077.

popliteal aneurism in females, and an immense number in males. John Hunter is represented as having said that he had seen only a single case of spontaneous aneurism in a woman. The explanation of this remarkable disproportion is thought by many to be due to a difference in occupations, men being engaged in those pursuits which demand great muscular efforts, while women are most concerned with employments of a lighter and less active nature. In certain sections of this country females labor in the fields, and are as much accustomed to the strain of out-door toil as are males. On the continent of Europe this farm-work of females is more commonly witnessed than in America. In neither country, however, is there any evidence that women who lead such a life are more subject to aneurism than their sisters whose industrial sphere is restricted to the duties of the house and family. I have long observed the freedom of females from atheromatous degeneration of the vessels, and to this constitutional peculiarity, perhaps more than to any other cause, are we to ascribe their exemption from aneurism.

Occupation.—As the laboring population furnishes the greatest number of aneurisms, we are very naturally led to infer that such employments as demand much muscular exertion predispose to the disease. Hayden, in his excellent work on the Heart and the Aorta, gives the analysis of 57 cases of aortic aneurism, with the following result as to occupation: 12 were mechanics, 10 soldiers or pensioners, 8 laborers, 5 porters, 4 cabmen, 4 gentlemen, 4 house-keepers (females), 2 grooms, 1 policeman, 1 butler, 1 tailor, 1 dairyman, 1 cattle-driver, 1 coal-heaver, 1 strolling player on wind instruments. Lawson* states that the deaths from aortic aneurism during 1866, in the English army, were eleven times more frequent than among the civil population. I do not believe that occupation, that is, the ordinary employments performed by the working population, can be placed among the predisposing causes of aneurism. There is nothing in honest labor to produce arterial degeneration. The fact of the disease being most commonly encountered in this class of our population should be ascribed to their greater numbers as compared with other classes, and to the combined influences of intemperance, exposure, and defective hygienic surroundings.

Nativity.—National peculiarities of constitution exercise considerable influence in favoring the development of aneurism. Billroth† states that, in Germany, aneurism of the extremities is rare. The disease is equally uncommon in Italy.‡ In France it is more frequent; and in England it prevails to a greater extent than in any other country. The number of deaths from aneurism alone in England and Wales, during five years,—from 1865 to 1870,—was 593.§ Among the native inhabitants of the United States the disease is not very common. Professor Gross‖ states that during a practice of twenty-three years in Ohio and in Kentucky he rarely met with a case of spontaneous aneurism. In Philadelphia the disease is less frequently seen than in New York,—the population in the latter city being less homogeneous than in the former. From 1865 to 1870, a period of five years, there were treated in the New York Hospital 11,344 cases of disease and injury, of which number 33 were aneurism.

Exciting causes.—Whatever causes undue stretching of a previously diseased artery, or produces a curve or an angle in its direction, becomes an exciting cause of aneurism. Under the first head come unusual muscular efforts, by which the vessel is overstrained; under the second head, any posture of the limb which creates an abrupt bend in the artery and thus exposes it to increased blood-pressure.

Emotional states, which quicken the force of the heart's action and increase the tension of the vessels, may excite aneurismal dilatation. It is the aorta which, from its nearness to the heart and the existence of an arch or curve, more particularly suffers from such influences.

Embolism is said occasionally to cause aneurism. A fragment of a blood-

* English Army Medical Reports, 1866. † Billroth's Surgical Pathology, p. 536.
‡ Crisp, p. 129. § Reports of the Registrar-General. ‖ Gross's Surgery, vol. i. p. 706.

clot or of a fibrinous clot may block up an artery and produce a dilatation of the vessel above the seat of obstruction. Tufnell* records a case of temporary dilatation of an artery from embolism, which subsided as soon as the collateral vessels were able to accommodate the circulation. The embolism was verified by dissection after the death of the patient.

Vessels affected.—All vessels are not equally prone to aneurism. The arch of the aorta, in point of frequency, stands first,—a fact which is probably due to the combined influence of structure, form, and blood-impact. This part of the vessel contains a large amount of elastic and comparatively little muscular tissue; its curve is sharply defined, and consequently the force which it is compelled to sustain at each contraction of the heart is very great. Lisfranc, in instituting a comparison between the different vessels, excluded the aorta, and found that, in 179 cases of aneurism, the popliteal was affected 59 times; the femoral in the groin 26, and at other points 16 times; the carotid 17 times; the subclavian 16 times; the axillary 14 times; external iliac 5 times; brachio-cephalic 4 times; brachial 3 times; common iliac 3 times; anterior tibial 3 times; gluteal twice; and the palmar arch once.

In 332 cases which I analyzed from a collection furnished me by Hunter, 145 were popliteal; 88 femoral, distributed as follows,—55 in the upper third of the vessel, 9 in the middle third, and 24 in the lower third; 21 carotid; 15 axillary; 13 innominate; 12 brachial; 12 subclavian; 9 intraorbital; 3 temporal; 3 gluteal; and 1 subscapular.

Symptoms.—The existence of external spontaneous aneurism may be deduced from the form and position of the swelling, from the manipulation and the auscultation of the tumor, and from the pressure-effects of the latter on surrounding parts.

Form.—Though aneurisms frequently differ in their outline, yet the prevailing form is either round or oval. The tumor may be when first discovered not larger than a marble.

Position.—Aneurism must occupy certain well-defined localities,—that is, it must appear in the course of a principal arterial vessel.

Manipulation.—1. The hand placed over an aneurismal tumor receives two distinct impulses, one of which is synchronous with the contraction of the left ventricle of the heart, and is generally very distinct, and the other answers to the dilatation of the left ventricle, and is a kind of tremor, produced by the rebound of the blood-column. The peculiarity of the first movement is its centrifugal character, expanding the tumor in all directions, and is very noticeable when the swelling is grasped on all sides with one hand, or when it is embraced between the two hands. 2. When the surgeon, or an assistant, applies a finger over the artery on the cardiac side of the tumor firmly enough to occlude the vessels temporarily, all movement or pulsation will be suspended in the swelling; and if the circulation continues to be controlled by the finger for some time, the tumor, being deprived of its supply of blood, will gradually diminish in size, and become soft and compressible. When the artery is again released from the pressure the swelling and pulsation will rapidly return. 3. If pressure be applied on the distal side of the tumor, interrupting the free escape of its blood, the impulse communicated to the hand will be sharp and abrupt, from the sudden arrest of the current, and will increase the distention of the sac. 4. The pulsation in the vessels below the aneurism is generally more feeble on the affected than on the sound side.

Auscultation.—When the ear is placed over an aneurism, a peculiar intermittent sound or bruit will be heard. This bruit was first observed by Ambroise Paré. This sound is sometimes blowing, sometimes purring, and at other times harsh and rasping.

Phenomena arising from the Pressure of the Tumor.—Œdematous swelling and distention of the subcutaneous veins in the parts below the tumor are not unfrequent accompaniments of aneurism, and are the effect of pressure upon a principal vein obstructing the return of blood towards the

* Dublin Quarterly Journal, May, 1853, p. 371.

heart. Pain, often of an acute, darting character, is also frequently experienced, in consequence of a nerve being pressed upon, or expanded over the surface of an enlarging sac. Numbness, coldness, and a tired feeling in the limbs are also symptoms caused by pressure.

Patients who suffer from aneurism are sometimes able to designate a time when, on making some unusual effort, they have experienced the feeling of something having given way, and, perhaps, a momentarily acute pain has been felt, as though a sharp blow had been delivered by some invisible hand.

Circumstances which modify Pulsation and Auscultation-Sounds.—When the opening between the sac and the artery is very small, or when the former is in a great measure filled with fibrin or with blood-clots, pulsation may be entirely wanting in an aneurism. In such cases pressure should be made on the proximal side of the tumor to empty it of its blood, when, the ear being placed over its surface, and the pressure being suddenly removed, the peculiar sound, faint though it may be, can sometimes be recognized as the current rushes into the sac.

Rupture of the aneurismal sac will generally be followed by the cessation of pulsation. Inflammatory infiltration between the integuments and the sac is also capable of masking pulsation.

The same causes which affect the pulsation in an aneurismal tumor may destroy or modify the auscultation-sounds,—for example, a small aperture between the vessel and its sac, or an obstruction of the opening by means of broken fragments of coagula. The bruit is generally most distinct when the sac does not contain much fibrinous deposit, and when its orifice is ample and irregular. Not only does the solidification of the contents of an aneurism diminish both its pulsation and its bruit, but it also renders it less soft and compressible than when the contents are fluid.

Diagnosis.—In a well-marked case of aneurism, the throbbing under the eye and the touch, the communication to the ear of strong blowing or high-pitched rasping sounds, the subsidence and the enlargement according as the artery with which the swelling is connected is compressed on the cardiac side or released from pressure, constitute such a group of significant phenomena that it would seem almost impossible that any error should be committed as to the nature of the disease. All cases, however, do not present such a collection of unmistakable symptoms, and, accordingly, we find the records of surgery contain a number of sad errors in diagnosis, committed, too, by men most eminent in the profession. Ferrand, Desault, and Dupuytren each opened an aneurism supposing it to be an abscess. The same mistake was made by Pirogoff. Three instances of a similar mistake have come under my own observation. In all the error proved fatal. In other cases operations have been undertaken for the cure of aneurism and the tumor has proved to be of an entirely different nature. Earle* ligated the subclavian artery for what was supposed to be an axillary aneurism but which was found to be a neuroma. It cannot be doubted that cases of great obscurity do occasionally arise in which the surgeon finds himself reduced to a state of indecision, incapable of advancing and yet unwilling to retreat without an immediate solution of the difficulty. These must, however, be exceedingly rare occurrences. As a general, after an unfortunate engagement in which he has sustained defeat and when the smoke and the tumult of the strife are past, can often, after a careful survey of the field, discover in some slight omission or trifling oversight the whole explanation of the disaster, so the surgeon who has been so unfortunate as to commit the blunder of thrusting a bistoury into an aneurismal sac will, generally, when he comes calmly to review all the circumstances attending the case, discover that but for some small neglect on his part all the evil might have been averted and the disease brought to a happy termination. Professional men of large and ripe experience attain, by constant contact with disease, a habit of forming their judgments by a kind of intuition. They are not conscious of any process of

* Medico-Chirurgical Transactions, vol. xxviii. p. 314.

ratiocination or of analysis, such as they toiled through in the earlier years of professional life. This is an acquisition which can never be imparted to others; it dies with the man. Such knowledge begets a degree of self-confidence which may sometimes betray its possessor into error. It is this feeling of personal infallibility which explains many surgical calamities,—it is the cause of that "holden vision" of which Pirogoff speaks.

The swellings with which aneurism may be confounded are *abscess* and *encephaloid disease, solid tumors, erectile growths,* and *cysts.*

Abscess.—An abscess may possess characteristics which render it not unlike an aneurism. The points in which the two diseases bear a fictitious resemblance are the following: both are round or oval in form; both present to the touch a degree of hardness and of softness; both may pulsate, and both may communicate a sound to the ear.

On a closer examination of the two swellings, however, it will not be difficult to distinguish the one from the other, as will appear by placing the two in contrast, as follows:

ANEURISM.	ABSCESS.
In aneurism the pain may be acute and paroxysmal, or dull and aching, not throbbing. The surface of the tumor is not tender, and there is absence of redness.	In abscess there is a previous history of inflammation, manifested by throbbing pain, heat, redness, and swelling.
In aneurism the tumor retains its usual round or oval figure, without becoming acuminate or changing color, except in rare cases, in which the sac becomes inflamed and suppurates.	In abscess the swelling, as it increases, tends to become pointed, and at the summit has a purple color.
In aneurism the induration begins by the deposition of fibrin at the circumference of the tumor, and advances inwards towards its centre.	In abscess the induration softens in the centre and extends towards the circumference.
In aneurism there will be no fluctuation, except in the few instances in which suppuration of the tumor takes place.	In abscess there will be, after a short time, fluctuation.
In aneurism the pulsation will be expansile or centrifugal, acting in all directions.	In abscess pulsation, when present, being due to an underlying vessel, will consist in a simple upheaval or rising and falling of the entire swelling.
In aneurism the pulsation is general, strong, and feels near to the hand when placed upon the surface of the swelling.	In abscess the pulsation is feeble, local, weak, and remote.
In aneurism the tumor cannot by manipulation be dislodged from its position, so as to arrest its pulsation.	An abscess can often be raised up or slid away from the vessel on which it rests, and the pulsation be stopped.
In aneurism the bruit in the tumor is loud, blowing, rasping, and whirring.	In abscess the sound communicated from the artery to the swelling in consequence of the pressure may have a blowing character, but never the thrill or purr of aneurism; generally the sound transmitted through an abscess to the ear is that of a dull, concentrated stroke.
In aneurism pressure on the proximal side will cause the swelling to subside and the thrill to disappear, both quickly reappearing on the removal of the pressure, while pressure on the distal side will increase the distention and size of the tumor.	In abscess the size of the swelling is in no way influenced by pressure either on its proximal or its distal side.
An aneurism when small may, by compressing its sides, be emptied of its liquid contents, but the tumor quickly refills on releasing it from compression.	An abscess, especially a cold lumbar abscess, when appearing in the groin below Poupart's ligament, may, by compression, have the pus pressed back into the pelvis, but when the pressure is removed it refills very slowly. In cold abscess there is also a long history of previous bone disease.
Aneurism is not attended with rigors, chills, and sweatings.	In abscess the formation of pus is usually announced by a rigor, and when the suppuration is large, by debilitating perspiration.

In some cases, as pointed out by Delpech, aneurism and abscess may coexist, the latter being formed in the tissues external to the former. Such was the condition in the unfortunate case in which Pirogoff laid open the sac of an aneurism supposing it to be a phlegmonous abscess. The well-known case

of Mr. Liston is sometimes mentioned as another example in point. The obscurity in such a combination is rendered still more perplexing, as the tension occasioned by the inflammatory infiltration of the parts between the sac and the skin will mask the pulsation of the tumor. In such a case a strict inquiry should be instituted to ascertain whether, previous to the condition which betokens the presence of suppuration, there existed a tumor; and, if so, whether it was a pulsating one. The ear and the stethoscope should also be employed to learn if any aneurismal sounds are present.

It has happened that an aneurism has opened into an abscess, in which case the ordinary characteristics of the former, such as pulsation and thrill, would be added to the latter. This occurrence is most likely to be realized in the axilla, in the neck, or in the popliteal regions, localities in which the loose textures around admit of an easy change in the position of growing tumors. The accident would have to be predicated on the pre-existence of a swelling which had suddenly become a pulsating tumor and yielded on auscultation the characteristic aneurismal thrill.

Solid tumors, scirrhous, fibrinous, or glandular, may be distinguished from aneurism by their dense structure, by the absence of pulsation and of thrill, and by their unchanging size, whether pressure be made on either their proximal or their distal side; all of which characters are unlike those of aneurism. Should such a tumor borrow pulsation from a vessel over which it is situated, the fact may be detected by shifting the position of the growth, or by insinuating the fingers beneath its base and separating it from the artery, when the pulsation will disappear.

Encephaloid growths, possessing, as they often do, a distinctive pulsation in consequence of their rich supply of vessels, are liable to be mistaken for aneurisms. No less distinguished surgeons than Mr. Guthrie, Mr. Moore,* and Mr. Stanley have tied the primitive iliac artery for tumors which were supposed to be aneurisms, but which on examination proved to be encephaloid. I was called not long since to ligate the carotid artery for a pulsating tumor in the neck, believed to be an aneurism. In this case the signs of the latter disease were so pronounced that not until a post-mortem examination was made, some months after, did one of the medical attendants believe that I was right in declining to tie the artery.

A careful consideration of the following particulars will generally conduct the surgeon to a proper diagnosis:

ANEURISM.	ENCEPHALOID GROWTH.
Aneurism is found generally in relation with a principal artery.	Encephaloid growths not necessarily near an important arterial trunk.
The aneurismal tumor usually regular and smooth in its outline.	Encephaloid tumor often irregular, having a number of prominences upon its surface.
Aneurism quite distinctly circumscribed.	Encephaloid disease usually without any sharply-defined limitations.
Aneurism generally grows slowly, and is painless unless a nerve be encroached upon.	Encephaloid disease grows rapidly, and is often very painful.
Aneurism at first is a soft, elastic swelling, becoming firmer and harder as it increases in age.	Encephaloid growths are hard at first, becoming spongy and soft as they progress.
Aneurism is a pulsating tumor from its commencement.	Pulsation is acquired after the disease has attained considerable bulk, and is never very distinct.
The sounds in aneurism are strong, blowing, rasping, and abruptly terminated.	The sounds in encephaloid disease are soft, subdued murmurs, and not sharply terminated.
Aneurisms diminish in size and sounds by pressure of the main artery on the cardiac side of the sac.	Encephaloid growths are little affected in their dimensions or in their sounds by pressure on the proximal side of the tumor.
Aneurism diminishes the force of the arterial pulse below the tumor.	Pulsation of the artery below encephaloid growths little if any affected.
The color of the skin natural over an aneurism.	As the disease advances, the skin over an encephaloid tumor becomes purple or lilac in color.
Glands in the vicinity of an aneurism remain unaffected.	Glands ultimately become enlarged in the neighborhood of encephaloid disease.

* Lancet, 1852, vol. i. p. 194.

No cachexia or emaciation in aneurism.	Both cachexia and emaciation in encephaloid disease.
The pulsation and bruit generally increase in intensity in proportion to the growth of the aneurism.	Pulsation and bruit not affected by the magnitude of the tumor.
Pulsation and bruit felt and heard at all points over an aneurism.	Pulsation and bruit often felt and heard over only portions of encephaloid growths.

Erectile growths bear a strong resemblance, in some instances, to aneurism. In the former, however, the swelling, when pressed between the fingers, has a spongy feel, unlike the sensation imparted by the elasticity of the latter, and the blood, when forced out of the cells of the growth, returns in an irregular manner, dilating the mass unequally,—very different from the regular distention of an aneurismal pouch. Nor are the pulsation or the sounds in erectile tumors counterparts of those in aneurism. In the first, the pulsation is quite feeble, and seems to consist of a number of disjoined throbs, instead of a uniform eccentric force reaching equally all parts of the sac. The bruit also of an erectile growth, being a soft, muffled sound, is in striking contrast with the whirr or the thrill of an aneurism. To these differential signs may be added the blue or red color of the skin, often present in erectile growths, and the absence of any enlargement of the tumor when pressure is applied on its distal side.

Cysts have been mistaken for aneurisms, and aneurisms for cysts. A case of each error has been recorded by Stephen Smith,* in a valuable paper entitled "Difficulties attending the Diagnosis of Aneurism." The absence of expansive pulsation and of a true bruit, together with only an unimportant subsidence of the tumor when the artery is compressed on its cardiac side, peculiarities which belong to pulsating cystic growths, would serve in most cases to establish their distinction from aneurism.

Aneurism has in a few instances been confounded with *rheumatism.* Such an error is probable in cases of aneurism of the abdominal or the thoracic aorta. In their early history, the dull, heavy ache in the loins or between the shoulders, which results from the contact of the tumor with the spinal column, simulates that of rheumatism. Careful auscultation, however, would undeceive the practitioner and enable him to refer the suffering to its proper source.

Holmes has spoken of the difficulty which attends the diagnosis of aneurism in which the usual signs of pulsation and bruit are absent,† and mentions a case involving the abdominal aorta. The same author makes a very important suggestion, viz., that the administration of an anæsthetic might, by taking off the tension of the abdominal walls, reveal the signs of an aneurism which under other circumstances could not be detected. Failure to ascertain the existence of such an aneurism, however, is practically of little moment, as no operation could be contemplated for its cure, even if properly recognized. A much more serious error would be to confound an aneurism which had undergone a spontaneous cure with a morbid growth, and remove (as was done in one case mentioned by Mr. Erichsen) a thigh for its cure.

Termination.—When an aneurism is allowed to progress without any surgical interference, it will terminate either in a spontaneous cure or in death.

Spontaneous cure.—This result is quite uncommon, though it is possible, even in the largest vessels. In one case of aneurism of the abdominal aorta which was under my care, the sac became solid, and was gradually disappearing at the time the patient left the city. Professor Gross‡ mentions a case of spontaneous cure in an aneurism of the subclavian artery, and Mr. Erichsen one in which the popliteal had undergone a similar change.

This mode of cure may be brought about in various ways: 1. By the deposition of fibrinous stratifications until the cavity of the sac is occluded, and the blood, no longer able to enter, is compelled to seek other channels. 2. In-

* American Journal of the Medical Sciences, Oct. 1873, p. 403.
† St. George's Hospital Reports, 1872–74, vol. vii. p. 192.
‡ Surgery, vol. i. p. 719.

flammation may attack the structures overlying the aneurism, and, extending to the sac, cause a thrombosis, similar to that in an inflamed artery, which may effectually close its cavity. 3. The aneurism may grow in a direction which will subject the artery upon which it is placed to a change in its course, or to such compression of its walls as will interrupt the force of the blood-current in the sac, and induce the formation of coagula within its walls. 4. A fragment of fibrin, or of blood-clot, becoming detached, may be swept into the vessel below, and by preventing the escape of blood from the sac produce a blood-stasis in its cavity favorable to coagulation. 5. Inflammation, followed by mortification, may attack the sac, in which case a coagulum forms not only in the aneurism, but also in the vessel which supplies it with blood. After the parts around become matted together by inflammatory adhesion, the slough, along with the grumous contents of the sac, becomes detached, and the chasm is repaired by granulation-tissue, if the constitutional resources of the patient are sufficient to endure the irritation. 6. Rupture of the sac followed by the escape of blood into the adjoining tissue, compressing the artery so as to cause its obliteration, is another rare mode of spontaneous cure. Such a case is mentioned by Sir Astley Cooper as having occurred in Guy's Hospital.* 7. Any constitutional cause which will diminish the power of the heart's action, and thereby weaken the force and the rapidity of the circulation, will tend to induce coagulation and the obliteration of an aneurismal tumor. The other termination is death, and may be caused either by sloughing or by rupture of the sac, followed by hemorrhage; or by the effects of pressure upon surrounding parts. The symptoms which indicate sloughing are, a circumscribed redness of the skin, tenderness to the touch, and finally the formation of a dark spot, which gradually extends and deepens, until the penetration of the sac is accomplished.

When the aneurism opens internally, without any break in the continuity of the skin, death may follow immediately; or, if the orifice be small and the resistance of the tissues around considerable, a clot may block up the vent and the flow of blood be stayed for some time, the patient ultimately, however, dying by a displacement of the coagulum and a renewal of the bleeding.

Treatment.—The treatment of aneurism is embraced under two heads, constitutional and local.

Constitutional.—Too much importance cannot be attached to the constitutional management of aneurism, even in cases where operative measures are contemplated. The great indication in the treatment of the disease is to secure the obliteration of the sac. In all sacculated aneurisms the deposition of fibrin begins almost simultaneously with the pouch-like protrusion of the arterial tunics, and along with this deposition occurs the formation of soft, red blood-clots. These processes are attempts at a spontaneous cure, and the surgeon, following the leadings of nature, endeavors to produce a similar result. The object being to favor the formation of fibrinous clots, whatever contributes to that end should be paramount. First, it is important to slow the circulation and to lessen its force. The method adopted by Valsalva for this purpose consisted in absolute rest, frequent venesections, purgations, and gradual starvation, until the patient was reduced to a condition of extreme debility, after which a nutritious diet was allowed, with a view to increase the plasticity of the blood. The plan is entirely too heroic for our modern notions of treatment, and indeed has been very wisely abandoned. A more rational procedure is that of Tufnell as employed in internal aneurism. The patient is confined to the recumbent position, not being allowed even to change his position in bed oftener than is necessary for personal comfort. A very spare though nutritious diet, chiefly of meat, and not exceeding eight ounces a day, is directed, and with no more water than is absolutely necessary. To prevent restlessness and procure sleep at night, chloral or morphia is given at bedtime. In Valsalva's plan the object was to lessen the

* Cooper's Surgical Dictionary, vol. i. p. 160.

quantity of blood and to weaken the strength of the patient, and consequently diminish the power of the heart's action, thus favoring the formation of a clot in the aneurism. But while it is true that the force of the heart was by these measures lessened, its frequency of action must undoubtedly have been increased. In Tufnell's plan, however, the object is not so much to lessen the power of the heart as it is to reduce its frequency of action, by the enforced rest and by the absence of stimulating food. The benefit to be derived from absolute rest of body and mind is of immense importance. The pain subsides, the aneurism beats less forcibly, it diminishes in size, and becomes more solid, circumstances which conduce to the comfort of the patient and to the prolongation of life. In conjunction with the treatment by rest, the iodide of potash, a remedy in great favor with Balfour, is sometimes administered, and with apparent benefit. The application of ice, first recommended by Guérin, of Bordeaux, has been extolled by some. I have no experience in its use. Hodgson, however, declares that it causes intolerable pain when applied to the tumor, and Broca charges the remedy with having produced mortification of the superincumbent skin, a result which I should apprehend as probable, from the low vitality of tissues stretched as these are over a large aneurism. Though internal aneurism may be considered an incurable disease, in some rare instances recovery has taken place.*

For several years I have been in the habit, before applying severe compression for the cure of external aneurism, of subjecting my patient, for six or eight days, to a preparatory course of treatment. This preliminary measure consists in confinement in the recumbent position, elevation and flexion of the limb when the aneurism is in the lower extremity, a restricted though nutritious diet, and the internal exhibition of tincture of aconite or of veratrum viride, in order to reduce the force and frequency of the heart's action. It is to this preparatory measure that I attribute, in some degree at least, the satisfactory results which I have realized from compression.

Local Measures.—Incision and Ligation.—This operation, among the earliest procedures for the cure of aneurism, and known generally as the plan of Antyllus, consisted, when possible, in first controlling the circulation through the tumor by compressing the vessel above, after which an incision was made directly into the aneurism over its entire length. The coagula being next turned out, the orifice of the artery leading into the sac was searched for by the finger or by a catheter, and, when discovered, the vessel was tied both above and below the tumor. The cavity of the sac was now packed lightly with lint, with a view to establish suppuration and granulation, by which the disease was expected to be obliterated. Keyslère, a surgeon in Italy, we are informed by Pelletan,† practiced this operation successfully, using only a single ligature on the cardiac side of the sac. The operation, in consequence of its fatality, has been very properly abandoned. Patients frequently died before leaving the table, from hemorrhage, or afterwards were worn out by hectic, in consequence of the profuse and prolonged suppuration which followed the operation. The late Mr. Syme, by adopting this method in the treatment of aneurism of the carotid, external iliac, and axillary arteries, has again given to the subject considerable surgical importance. Gay has also applied this plan to the femoral, and Henry Smith to the popliteal. In cases of spontaneous aneurism, arising from a diseased state of the vessels, the folly of placing a ligature on the artery contiguous to the sac has been well demonstrated. When the blunder is committed of cutting into an aneurism supposing it to be an abscess, this operation then assumes a truly practical importance, as, in my judgment, it is the proper one to be adopted in such event.

Ligation.—Until the time that the proper use of the ligature was recognized for the cure of aneurism, surgeons seem to have possessed no intelligent comprehension of nature's method of cure. It was deemed necessary, what-

* See Tufnell, Transactions of the International Congress at Philadelphia, 1876.
† Pelletan, Clinical Surgery.

ever plan was adopted, that the tumor should be removed in its totality; and hence arose the practice of opening the sac, turning out its contents, and staunching the hemorrhage by the cautery, by the ligature above and below the disease, or by the still more radical measure of amputating the limb. To British surgery is the world indebted for rescuing this subject from the domain of conjecture and placing it on a philosophical basis. Until the proposition made by John Hunter, in 1785, of tying the vessel on the cardiac side at a point remote from the disease, the mortality from aneurism was very great. The French, as is well known to medical readers, claim for one of their countrymen, Anel, the honor of having made the first practical application of this principle; but there is very little resemblance between the two operations, except in the fact of their being both on the proximal side of the sac. That of Anel was done seventy years before that of Hunter,—in 1710. The subject of the operation was an Italian priest, who, in consequence of a wound of the brachial artery made during venesection, suffered from an aneurism at the bend of the arm, which, two weeks after the injury, commenced to bleed from the original wound. Anel exposed the artery close to the sac and surrounded it with a ligature. All pulsation immediately ceased in the swelling, and the patient quickly recovered. The operation performed by Hunter was for popliteal aneurism in a coachman admitted into St. George's Hospital. The femoral artery was exposed and gently compressed by four ligatures,—the object of this multiplication of threads being to affect a considerable extent of the vessel by moderate pressure, rather than to concentrate the force of a single ligature on a small portion of its walls. Pulsation disappeared in the aneurism, and it gradually disappeared by absorption, the patient perfectly recovering. If we now contrast the two operations it will be seen how widely they differ. In the case of Anel the aneurism was traumatic in its character, and the presumption is that he had to deal with a sound vessel. In the case of Hunter the aneurism was spontaneous, and was doubtless dependent upon a diseased state of the arterial tunics. Again, in the case of Anel the ligature was applied close to the sac on its cardiac side; in the case of Hunter the artery was tied also on the cardiac side, but distant from the aneurism,—namely, at the femoral, where it was supposed the vessel would be found sound. The operation of Desault (also claimed as taking precedence of that of Hunter), except in the fact of its being done on a different vessel,—the popliteal,—and for spontaneous instead of traumatic aneurism, is in all respects like that of Anel. There are other points connected with these two historic operations of Hunter and Anel which tend to show that with the former the operation was predetermined by a course of reasoning, while that of Anel was the result of an emergency and undertaken without any fixed convictions of what was to follow. In Hunter's procedure are implied the probability of finding a healthy condition of the arterial walls; the possibility of curing an aneurism without entirely depriving it of blood; the utilization of the coagula as a means of occluding the sac; and the sufficiency of the collateral vessels to maintain the circulation and the vitality of the parts below. There is no evidence that the mind of Anel had grasped any one of these important principles.

The Hunterian operation, whenever the ligature is employed for the cure of spontaneous aneurism, should be adopted; that is, in an aneurism of the popliteal the ligature should be applied to the femoral artery, and in an aneurism of the femoral the external iliac should be tied. Various kinds of thread are in use among surgeons. Silk, hemp, silver wire, lead wire, and catgut have each their advocates. I prefer in all cases to employ the animal thread, cutting off both ends and closing up the wound. This ligature has never yet failed in my hands, even when applied to vessels the size of the external iliac. Acting upon a suggestion received from Mr. Lister, I requested Dr. Wharton, one of the resident physicians in the University Hospital, to treat a number of specimens of catgut which had been subjected for some time to the action of carbolic acid and sweet oil, with chromic acid and glycerin. After several

experiments, Dr. Wharton found that three grains of the acid to the ounce of glycerin produced a soft, supple state of the thread, depriving it of all tendency to the spontaneous untying of the knots which were placed upon it. Catgut prepared in this way does not require to be subjected, as a preliminary measure, for more than two weeks to the antiseptic mixture of carbolic acid and olive oil.

When the ligature is applied, after the Hunterian plan, at a point distant from the disease, the pulsation and the bruit immediately cease in the aneurism, as all direct communication between the blood in the vessel and that in the tumor is intercepted. There is likewise a sensible diminution in the size of the swelling. Not only does the ligature interrupt the circulation through the vessel which it surrounds, but it also arrests at the same point the force transmitted from the heart, in consequence of which there follows congestion of the capillaries and venous trunks below. This condition is succeeded by a sensible rise in the temperature of the limb. In several instances, immediately after ligating the femoral or the iliac for aneurism, I found this elevation of temperature of the limb on the affected side to be greater than on the sound side. The blood arrested in its course through the main channel immediately seeks the collateral branches, which undergo rapid dilatation, and in a short time become sufficiently capacious to answer all the demands of the parts below. (Fig. 381.) With the diminished supply of blood there is also a noticeable loss both of nerve-power and of sensibility in the limb. The patient is unable to move the part as before, and it may be a long time after recovery before this muscular disability passes away. The same care as in paralysis is necessary to prevent the heel and other parts of the extremity from becoming sore. In addition to the impairment of its nervous functions, the limb becomes somewhat wasted. All of these phenomena are defects of nutrition, and proceed from one and the same cause, viz., a defective supply and an unequal distribution of blood. Though the main channel to the aneurism is interrupted by the ligature, the circulation in the tumor is not entirely arrested. The blood reaches it through the collateral vessels, and sometimes in sufficient quantities to be recognized by the presence of a feeble pulsation. This is especially true if the treatment by pressure has preceded that by ligature, in which case the anastomosing vessels have already been considerably dilated. This circulation, however, in the tumor in no way interferes with the progress of the cure: on the contrary, it renders it more certain and safe, by favoring the deposition of fibrinous lamellæ. Were an absolute stasis of the blood in the aneurism to follow ligation, the sudden formation of a large mass of coagulum might become an irritant, and cause inflammation, suppuration, and sloughing of the sac.

Fig. 381.

Collateral circulation after ligature of the femoral.

Causes which render the Ligature ineffectual.—The causes which defeat the cure of an aneurism after ligation by the method of Hunter are the following:

1. *Secondary hemorrhage.*—This may result either from a diseased state of the vessel, rendering the detachment of the ligature premature and the process of healing defective; from the opening of the sac; or in consequence of a peculiar state of the blood inimical to coagulation.

2. *Too free a supply of blood by anastomosis.*—When the collateral vessels are large and the circulation in the tumor is not sufficiently diminished to allow of the rapid deposit of fibrin, the consolidation of the aneurism may be prevented. It is probable that in some cases, in which the pulsation has

returned strongly in an aneurism after ligature, there is an unusual arrangement of the vessels, or the clot within the sac is displaced, rendering its cavity again pervious to the passage of blood. The latter occurred in a case of popliteal aneurism which I once had under care. In evidence of this, the foot became gangrenous from the plugging of its vessels by the detached thrombi. The case mentioned by Erichsen, of two femoral arteries supplying a popliteal aneurism, which was operated on by Sir Charles Bell, one vessel only having been tied, will serve to show, though the tumor was cured, that such an anomalous distribution may have been present in some instances of returning pulsation which have been recorded by writers. There are, however, examples in which pulsation and bruit in aneurism cured by the ligature have returned and disappeared several times, or have reappeared after the disease had been cured several years, and which evidently depended on the strength of the circulation in the anastomosing vessels supplying the sac. In the case of femoral aneurism operated on by Sir Benjamin Brodie and recorded by Mr. Prescott Hewett,* pulsation and thrill returned five and a half months after ligation of the iliac. Under rest and pressure these symptoms disappeared. Two years later there was a recurrence of the pulsation, but no increase in size. Two months after this the tumor began to increase in size, but without either pulsation or bruit, and finally, after attaining the bulk of an ostrich-egg, began to diminish, and underwent a spontaneous cure, as was satisfactorily ascertained by an examination after death, the patient having died of phthisis. An aneurism may, in consequence of the rich supply of anastomosing vessels, become active, though that activity may manifest itself only in the growth of the tumor, all sounds and movement being absent. Sir Astley Cooper mentions a case of popliteal aneurism in which he tied the femoral, and, as he supposed, with a successful result. Some time after, the swelling, without pulsation, began to increase in size, attended with such suffering as induced him to amputate the limb. H. L. Brown, of West Bromwich, England,† tied the primitive carotid for an aneurism of the external carotid. Five years after, the tumor again commenced growing, but without pulsation. Oliver Pemberton, Surgeon to the General Hospital, Birmingham,‡ tied the external iliac for femoral aneurism. Two years and a half afterwards, the old tumor began to enlarge, though without pulsation or sound. In such cases as these the increase in size is due to additional depositions of fibrin in the course of the newly-formed channels through the old stratifications of clot. When the aneurismal sac is pedunculated, or stands off from the artery, the circulation through the latter may be entirely restored by means of the collateral vessels, without in any way reproducing the aneurism.

The treatment required for cases in which the aneurism has again become active, with or without pulsation, is rest in the recumbent position, with the application of firm pressure to the entire limb, including the tumor, by means of a roller bandage. This failing, the pressure may be conjoined with flexion of the leg upon the thigh, and of the thigh upon the abdomen; and, finally, should all fail, an Esmarch elastic bandage may be adjusted to the limb with a moderate degree of firmness and kept in place for half an hour daily for several days, observing to remove it each time gradually, and afterwards to keep the part elevated.

Opening of the Sac.—Opening of the sac after ligation may take place in three ways,—by suppuration, by mortification, or by rupture.

Suppuration.—Should suppuration follow the ligation of the artery it will be announced by the usual signs of inflammation, namely, increased swelling, heat, redness, and pain, attended by the constitutional disturbances ordinarily accompanying abscess, such as rigor, an accelerated circulation, and occasionally perspiration. The tumor, though it may have diminished in size for a short time after the operation, now enlarges, throbs, becomes acuminate,

* Medico-Chirurgical Transactions, vol. ix.; Lancet, July, 1877.
† Lancet, July 28, 1877, p. 121. ‡ Ibid.

and finally opens, exposing the interior of the sac, the contents of which have become softened and converted into a dark-colored paste or fluid by the disintegration and admixture of the fibrin and other blood-clots of the aneurism. After this accident, should the communications not be closed between the artery and the sac above and below, a sudden gush of blood may instantly destroy the patient, or, if this does not follow, life will be jeopardized by repeated attacks of bleeding. The danger from suppuration of the sac is lessened the longer the process is delayed, as time is allowed for permanently interrupting the continuity between the vessel and the aneurism. Large aneurisms are more prone to suppurate than small ones, and there is no period, from three or four days up to as many months, in which a patient can be said to be exempt from such a risk. A broken state of the general health, or the sudden transformation of the contents of the sac into a blood-clot instead of the orderly fibrinous deposition, may be placed among the exciting causes of this accident.

Sloughing may, like suppuration, be preceded by inflammatory symptoms, or the first indication of the change may be a small black speck on the surface of the tumor, which gradually enlarges and deepens until the attenuated tissues are penetrated, when results similar to those which follow suppuration ensue. Frequently before the mortification sets in, the contents of the aneurism, which may have been quite firm, begin to soften. Hemorrhage does not necessarily immediately follow the detachment of the slough; several days may elapse, in which broken-down grumous blood is discharged before bleeding sets in. In one case under my care it was six days between the opening of the sac and the occurrence of hemorrhage. The bleeding generally is from the distal side of the aneurism.

Rupture, except from suppuration and from mortification, is an exceedingly rare result.

TREATMENT.—Suppuration once established, there is no longer any necessity for delay; the surgeon should proceed at once to lay open the sac, as the longer the softened contents of the aneurism are retained the greater will be the probability of the destruction of any reparative work which may have been done in the vessel, and of the parts becoming flooded with blood. Previously, however, to opening the sac, every precaution should be taken to provide against hemorrhage. A tourniquet must be placed over the artery above, or, when this is not feasible, other resources should be at hand, as the fingers of an assistant, the padded door-key, or possibly graduated compresses. If the suppuration has taken place some weeks after ligation, the sac may have no direct vascular connection with the artery, in which case nothing more will be required than to dress the abscess with a carbolated water-dressing until the disorganized blood and fibrin have been discharged, when the cavity may be lightly packed with lint steeped in carbolic acid and olive oil. In a short time granulations will spring up, and the chasm be gradually repaired. The surgeon, however, must never relax his vigilance, even in cases where no hemorrhage immediately follows the opening of the sac; it may break out at any moment, and therefore the tourniquet should be kept in position, ready to be screwed down at a moment's notice, and the most minute instructions communicated to the nurse, or to other attendants, to thrust the fingers or properly-constructed compresses into the sac when the tourniquet is not practicable.

Hemorrhage, whether from separation of the ligature or from opening of the sac, is not a very frequent occurrence, but generally is most unpromising to the life of the patient when it does take place. In 180 cases collected by Lisfranc, it followed in 32. In the 530 cases examined by Porta, it occurred 73 times. The tables of Norris contain 300 cases of ligature for aneurism, in 49 of which secondary hemorrhage took place. In 314 cases of aneurism collected for me by Hunter and Griffiths, 37, so far as could be ascertained, suffered from secondary hemorrhage after ligature.

When the bleeding comes from the seat of ligature, either out of the

proximal or the distal end of the vessel, the hemorrhage must be controlled by direct pressure with the fingers, aided, if necessary, by a graduated compress; or a tourniquet, when feasible, may be placed over the vessel. The wound should be next opened, and, after being enlarged upwards and downwards, a ligature must be placed on both the proximal and the distal portion of the artery. If the hemorrhage is again repeated, and from the distal end of the vessel, there is no alternative but to amputate.

When the bleeding comes from the sac, the surgeon has five courses open to his election: first, to lay open the sac and tie the artery above and below; second, to tie the artery above the seat of the first ligature; third, to apply compression above and below the tumor, or to stuff it with lint; fourth, to use the actual cautery; and, fifth, to amputate. To tie the vessel close to the sac is to include portions of the artery most certainly diseased, with the prospect of an early recurrence of the hemorrhage when the ligatures become detached; and hence the operation has uniformly failed. To tie the artery above the seat of the previous ligature, while it may reach a sound part of the vessel, cannot materially affect the circulation through the collateral vessels, the connection of which branches with the sac constitutes the source of the bleeding. Compression, within or without the sac, is attended with equal uncertainty. When externally applied, it can be endured for but a short time, and when used internally, it can act only as a stopper, which, when detached, again allows the blood-flow. A possible result of internal pressure by stuffing the sac is the closure of the bleeding vessel or vessels by an extension of the inflammation and the suppuration beyond the limits of the sac, from the irritation caused by the presence of the foreign body used in packing its cavity. Sealing up the vessel by the hot iron has proved successful in one case, that of Morrison;* and when there is reason to believe the bleeding comes from a small branch, the cautery should be tried. To remove the limb may not always be feasible, but when this is possible it offers the patient, in my judgment, the best prospect of life.

MORTIFICATION.—Mortification of the parts below the ligature is confined chiefly to the lower extremity, and arises from an inadequate supply of blood through the collateral vessels. This defect is not attributable to the want of a sufficient number of anastomosing arteries. In this respect all persons are nearly equally supplied, though the capacity of these branches may differ. Mr. Syme believed that mortification was always the result of injury to the vein. Twice have I seen this accident occur without any evil effects whatever, and a number of cases are recorded in which the femoral vein has been tied, either by accident or by design, with impunity. It is more reasonable to refer the death of the limb to obstruction of the profunda femoris artery by coagula, and to a feeble heart, unable to drive the blood onwards with sufficient power to dilate properly the branches of the compensating system of vessels. An additional impediment to the collateral circulation may be an aneurismal sac of unusual size.

Statistics show that mortification is not an uncommon result after the ligature of vessels for aneurism. In 300 cases tabulated by Norris, it followed 40 times, 28 of this number taking place after ligature of the femoral. In a collection of 222 cases furnished me by Drs. Hunter and Griffiths, mortification was observed to occur 29 times. According to Porta, 71 per cent. of patients attacked by gangrene after ligature die. The disease may prove to be very limited, affecting only two or three of the toes, when the collateral circulation has been imperfectly established, though generally it extends rapidly up the limb, and is of the acute, moist form. The period at which mortification commences is usually within two days after the application of the ligature.

The fatality, from all causes, attending the ligature of vessels for the cure of aneurism is greater, perhaps, than is generally supposed. The tables of the late Dr. George Norris contain 379 cases, of which number 127 died. Of

* Norris's Contributions to Practical Surgery, p. 245.

169 cases of ligature for aneurism,* 49 proved fatal, or 29 per cent.; and of 50 cases collected by Dr. Griffiths,† 7 were followed by death, or 14 per cent. These results do not materially differ from those of Porta and Lisfranc, the former giving a mortality of 117 out of 418 cases, and the latter a mortality of 38 out of 125 cases. Between 1868 and 1876 there were 28 cases of aneurism treated by the ligature in the Pennsylvania Hospital:‡ 20 of these recovered, and 8 died. The arteries ligated for the cure of these aneurisms were as follows: common carotid 6 times, with 2 cures and 4 deaths; subclavian once, with 1 cure; common iliac, once, 1 cure; external iliac, 4 times, with 3 cures and 1 death; femoral, 13 times, with 10 cures and 3 deaths; anterior tibial, once, with 1 cure; and the brachial, once, with 2 cures.

Treatment of Mortification.—In order to favor the restoration of the circulation, the limb should not be surrounded by a roller, as is sometimes done after ligature of the main vessel. Nor should it be elevated above the plane of the body. With a view to maintain the temperature of the part, the extremity must be enveloped in a thick wrap of cotton, and a bottle of hot water, rolled in a piece of flannel, applied to the sole of the foot. The fact that the limb is preternaturally warm after ligature, as has been previously stated, in no way contra-indicates the use of external or artificial heat. The warmth following the operation is due to stasis, not to an acceleration of the blood-current, and is no expression of an increased vitality; rather, indeed, is it allied to the caloric which inaugurates tissue-decomposition. The diet must be regulated in accordance with the condition of the patient. When the constitution is broken by long suffering or by previous bad habits, the food should be nutritious and easily digested, assisted by tonics and stimulants. If the person is vigorous, the diet should be free from all stimulating qualities, and for the first three days moderate in quantity.

When mortification commences, the surgeon must be guided in his treatment by the peculiarities of the case. If the disease lingers about the toes, or creeps up the foot very slowly, it is better to delay the use of the knife. In such cases there is a reasonable hope that the death may be confined to a very limited portion of the limb, and it is wise to wait until the process defines its own boundaries, after which the part may be removed. Of 49 cases of mortification following ligation, according to Porta, 14 recovered, 10 without and 4 with amputation. During the period of uncertainty the system should receive every possible assistance in the work of establishing the circulation. External heat must be kept up; the diet must be liberal, with quinine and alcoholic stimulants; and opium must be administered when necessary to relieve pain or procure rest. When, however, the disease is well pronounced, and extends rapidly over the foot and ankle to the leg, all temporizing should be abandoned, and amputation immediately performed. The limb should be removed a short distance below the place where the ligature was applied. The presumption is that the collateral circulation has been sufficiently formed in a part of the extremity, and hence it is not necessary to apply the knife close up to the point where the artery is tied.

There is a state of incipient gangrene indicated by œdema and by discoloration of the foot, produced by the pressure of a large sac, which, although not sufficient to arrest the circulation before the application of the ligature, yet afterwards, when the force of the blood is diminished, begins to produce threatening effects. In such cases it will be proper to lay open the sac and remove the pressure by turning out its contents.

Tetanus, though an unusual sequence of ligature for aneurism, does occasionally follow. Three cases of this kind, after ligature of the femoral, are tabulated by Norris. May it not be possible that a branch of the anterior crural nerve, which lies close by the side of the artery, was tied with the vessel in these cases?

* Hunter,—manuscript collection. † Griffiths,—manuscript collection.

‡ Morton's Tables of Ligature of Large Arteries at the Pennsylvania Hospital, American Journal of the Medical Sciences, April, 1876.

Erysipelas and *phlebitis* have also followed this operation; though their occurrence is exceedingly rare.

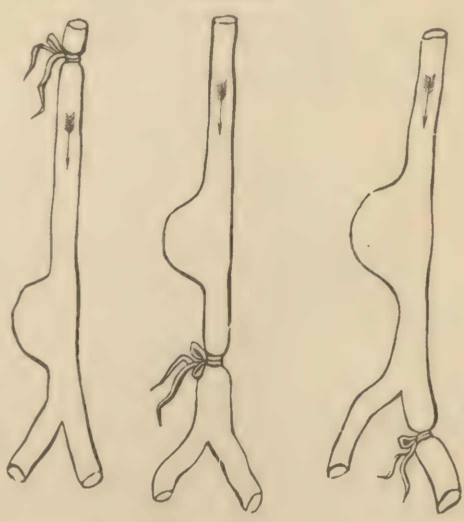
Apoplexy and *paralysis* have in several instances occurred after ligature of the carotid.

Ulceration of the artery above the seat of ligation may open the vessel and give rise to fatal hemorrhage. Twice have I seen this occur.

Statistics sufficiently extensive are as yet wanting to enable us to make a comparison between the silk or the hemp ligature and the catgut thread; but I am encouraged to believe that when a sufficient number of cases can be collected to warrant a deduction, it will be found that the animal thread has lessened the mortality following the ligature of arteries for aneurism. In the 168 cases of ligature for aneurisms which I have spoken of, there were 13 arteries tied with catgut thread, as follows: 6 popliteal, 3 femoral, 2 external iliac, and 1 brachial, with 12 recoveries and 1 death.

Ligature of the Artery on the Distal Side.—In consequence of the inaccessible position of certain aneurisms rendering it impossible to place a ligature between the tumor and the heart, the idea was conceived of interrupting with the ligature the circulation on the distal side of the swelling. This operation bears the name of Brasdor, a French surgeon of Paris, and was advocated about the same time by Desault. It was put in execution by Deschamps, who tied the femoral artery below an aneurism of this vessel situated in the groin. The operation, however, was not successful. The principle involved in the mode of treatment will be better understood when the effects of such a disposition of the ligature are understood. The interruption of the blood-current from the sac when the artery is tied on its distal side is followed by the same demand on the collateral branches to provide for the circulation below, as when the vessel is tied above the aneurism. The enlargement of these circuitous channels meets this emergency, and tends to divert the blood in some measure from the sac, while the abrupt closure of the outlet from the latter has the effect of both slowing the blood-flow and producing counter-currents in the aneurism, two conditions which conspire to determine a fibrinous deposition, the usual method of cure. Sir Astley Cooper, after Deschamps, tied the femoral for a case of external iliac aneurism on this principle, but with only temporary success, as the patient, some time after the detachment of the ligature, died, probably from a rupture of the sac. In 1825, in a case of aneurism of the carotid at the root of the neck, in an aged female, Wardrop, of London, made the first successful operation, after the Brasdor plan, by tying the vessel above the tumor, the patient making a complete recovery. The operation has been repeated a number of times, but with very indifferent success. Of 38 cases collected by Erichsen, 25 proved fatal, and in the remaining 13 the disease was not arrested. Two years after his first operation, Wardrop tied successfully the subclavian for an aneurism of the innominate artery, applying the principle of Brasdor, by including a branch of the diseased artery instead of the vessel itself. This is known as the Wardrop method. There are, therefore, four modes of ligating arteries for aneurism, two on the cardiac and two on the

Fig. 382.



Hunter. Brasdor. Wardrop.

distal side of the tumor. The first two are those of Anel and Hunter, the last two those of Brasdor and Wardrop. The preceding cuts (Fig. 382) will exhibit the distinction between these plans.

Compression.—This method dates back to a very early period, having been employed about the end of the seventeenth century for the cure of aneurism by Bardelot. It was afterwards practiced by Heister, Guattani, Ciniselli, Flajani, and others. Based, however, as this old plan of compression was, on a misconception of natural processes of cure, it met with little success. Its advocates, entertaining views like those inculcated by Scarpa, viz., that the cavity of the vessel was to be obliterated by the adhesion of its sides, applied their compression directly over the aneurism, by pads of various materials and by roller bandages, in order to force the blood out of the tumor and bring its surfaces in contact with each other. The principle of the cure of the disease by the deposition of fibrinous coagula was evidently not understood. The earliest mode of applying pressure was, first, directly upon the sac, as stated above; secondly, immediately upon the artery above the sac; and; thirdly, intermediately upon the vessel above the sac.

By the first plan the surgeon attempted an impossibility, the emptying of the contents of the aneurism. The strata of fibrin, being solid, and closely applied to the inner surface of the tumor, could not be forced out of its cavity, while by displacing the fluid part of the blood he excluded the very material which was required to cure the disease, preventing the further deposition of fibrin. Aside from these objections, the danger of causing mortification, by blocking up the vessels leading from the aneurism by thrombi or by emboli, must have been very great.

Immediate pressure applied to the artery was introduced about the close of the eighteenth century, by Cline, Deschamps, Percy, Assalini, and others. By this method the artery was exposed above the sac, and embraced temporarily, that is, for twenty-four or thirty-six hours, by some constricting medium. The earlier innovators used an ordinary broad ligature, interposing between it and the vessel a little roll of linen or a piece of soft wood like cork. Cline employed tapes, which he tied over a cylinder of cork; while Deschamps, Percy, Dubois, and Assalini used artery compressors, similar in appearance to canulas, and the forceps. Cures were occasionally effected in this way, not, as was supposed, by adhesion of the sides of the compressed vessel interrupting all communication between it and the sac, but by the rapid coagulation of the blood within the latter, just as occurs after one mode of using complete pressure at the present time. The dangers of this plan are quite sufficient for its condemnation. An artery cannot be temporarily compressed with impunity, even though the force be merely sufficient to arrest the passage of the blood through its canal. Ulceration of its coats is liable to follow; and, even should this not occur, it is difficult to understand what advantage this form of pressure could have over the old ligature. On the contrary, the result of later experiments establishes the superiority of the latter in point both of efficacy and of safety.

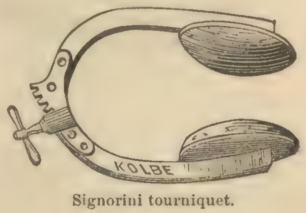
In 1810, intermediate pressure, made over the course of the artery above the aneurism, was introduced by Pelletan and Dubois; yet these surgeons, as well as those who immediately followed them, seem to have been possessed with the old notion that there must be a complete obliteration of the canal of the artery. To give effectiveness to this idea necessitated the application of such a degree of force that few persons could tolerate the treatment, and consequently this plan fell into discredit, except as a measure preliminary to ligation, for which purpose it was regarded with favor by Todd, the object being to prepare the collateral vessels for the work of carrying on the circulation when the blood should be arrested in the main channel. It remained, however, for the surgeons of Dublin to solve this vexed question, to which the thought of the profession had clung with a singular tenacity. To Bellingham, Tufnell, Hutton, and Carte are we indebted for the principle, as well as for the most thorough practical demonstration of its application in the

cure of aneurism by compression. Properly speaking, this principle was not a new announcement, but only another application of that established by Hunter in the use of the ligature. This pressure may be complete or incomplete; that is, the current through the artery may be entirely arrested, or only partially so. Murray, of Newcastle-on-Tyne, who adopts the former plan, which, it will be perceived, is a revival of the method of Pelletan, has shown that an absolute stasis of the blood of the sac is entirely compatible with a safe and rapid consolidation of its contents. O'Ferrall, of Dublin, has somewhat extended the principle of inducing complete stagnation of the circulation in the aneurism, by applying compression simultaneously on both sides of the sac. The majority of the Dublin surgeons, on the contrary, prefer the partial interruption of the blood-current, as calculated to produce both a safer and a more certain cure, by closing the sac with orderly, solid stratifications of fibrin, rather than by causing the sudden formation of a soft blood-clot. That excellent cures are effected by both procedures cannot be doubted. I cannot conceive why there should be any more risk in completely arresting the current of blood in the sac by pressure than by the ligature. In practice I always adopt the rule of complete pressure, and I have seen nothing as yet to induce me to abandon this plan. On the whole, it would be wisest not to pronounce dogmatically on the relative merits of the two theories until we are in possession of larger data from which to draw a deduction.

Preparation for compression.—A patient suffering from aneurism, who is to be subjected to this mode of treatment, requires some preliminary treatment. To this I attach much importance. The entire process, in all its details, should be explained to the patient, that we may enlist his interest and his intelligent co-operation in the treatment. He should be placed upon a well-stuffed mattress. Nothing can be more unsatisfactory than a soft bed, into which the hips of the person sink. A few pillows must be provided, with which to raise the head and shoulders of the patient, and on which the outer side of his semi-flexed limb may rest. For three or four days previous to beginning pressure, absolute rest in the recumbent position should be enforced. The person should not rise either to pass urine or to defecate; the diet must be restricted in quantity, though not materially altered in quality, and the action of the heart diminished in force and in frequency by repeated doses of veratrum viride. If the patient is aged and feeble, such a course would be obviously improper, and we may be content to exact only the prescribed quietude in bed. When the active part of the treatment begins, the diet should be both liberal and nutritious, such as milk, animal broths, and eggs. It will be necessary, also, to detail at least four assistants to attend the case, persons reasonably well instructed in medicine, two of whom shall be on duty at the same time, and who shall alternate every six hours.

Means for applying compression.—These are instrumental and digital. A great number of contrivances have been devised for instrumental compression. The great indication in the construction of an apparatus for this purpose is that the extremity shall not be constricted so as to interrupt the venous circulation,—that is, that pressure shall be exerted only upon two portions of the limb, over the vessel and over the surface directly opposite. Sometimes this is accomplished by means of the Signorini tourniquet (Fig. 383) or some one of its various modifications, such as the Bellingham clamp (Fig. 384), or one of the Carte compressors (Figs. 385 and 386), which have the merit of being more fixed when placed in position. The instrument of Dr. P. H. Watson (Fig. 387) is preferred by some, as the peculiar form of its weight enables the surgeon to concentrate the pressure more effectively than by the ordinary pad. In order to distribute the compression, or to alternate it at different points over the course of the artery, compressors have been constructed with

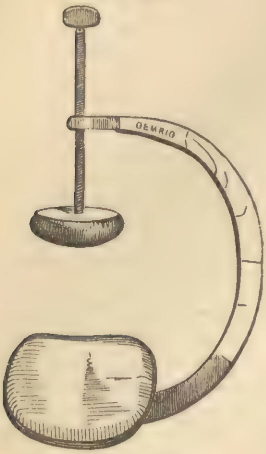
FIG. 383.



Signorini tourniquet.

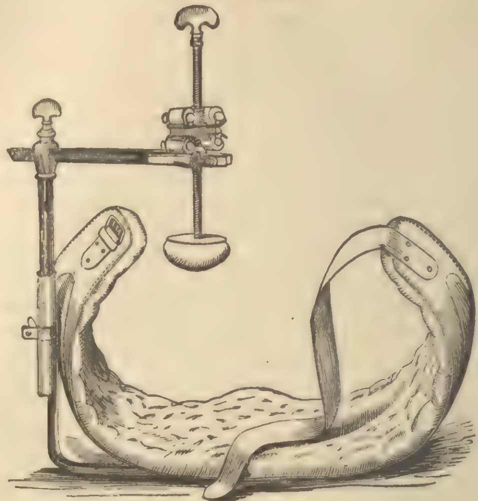
two or more pads. (Figs. 388 and 389.) By such a modification one pad, after being run down over the vessel and kept in place for a time, can be

Fig. 384.



Bellingham clamp.

Fig. 385.



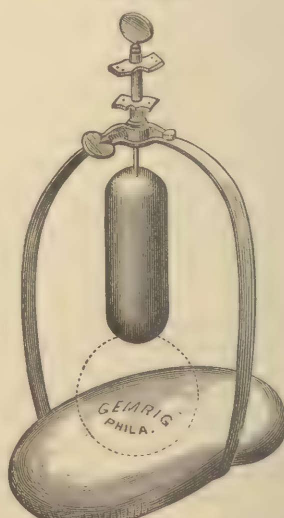
Carte's compressor.

elevated, while the circulation is still controlled by a second being screwed down before the other is raised. The objection to the use of the Charrière, the Briddon, or any other form of compressor which has a linear arrangement of pads, is that the pressure cannot be conducted on the one artery

Fig. 386.

Carte's circular compressor.

Fig. 387.

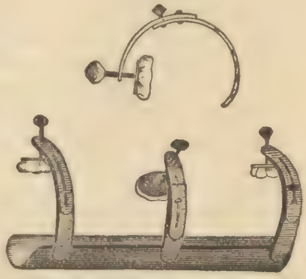


Watson's weight compressor.

system, which Mr. Walker, of Liverpool, deems so important, as the pads affect different portions of the vessel, and are necessarily constantly changing the collateral circulation from one series of vessels to another. For example, when the pressure is applied to the superficial femoral the blood will be turned into the profunda and its branches, and when it is changed to the common femoral the circulation will have to seek a passage through the circumflex, obturator, and other branches of the internal iliac. The impor-

tance of this theory I believe to be greatly over-estimated, and, as far as my own observation extends, it is not sustained by facts. Whatever form of apparatus is adopted, soft compresses must be placed between the body of the instrument, the pads, and the parts against which these rest. If it is proposed to arrest entirely the circulation through the artery, the force required to effect this will be greater than can long be endured by the patient, in which case it will be necessary to administer an anæsthetic. The use of this agent as an adjuvant in the treatment of aneurism was, I believe, introduced by Dr. Murray contemporaneously with his method of complete pressure. I have kept a patient during the pressure under the influence of ether continuously for seven or eight hours, without the least inconvenience. When the plan of only slowing, not of entirely interrupting, the circulation in the sac is adopted, the instrument, after being adjusted to the limb, must be gradually tightened, *just to the point*—not beyond it—of inability to recognize pulsation in the aneurism when the hand is laid over its surface; and to insure this degree of pressure it will be necessary to apply this test from time to time. I have seen an intelligent patient, guided by his own sensations, tighten the instrument when necessary. Tolerance to this pressure can usually be obtained by the hypodermic use of morphia. To secure the most satisfactory action of the drug, it should be administered to the patient on the earliest evidence of distress, before he becomes restless and agitated, and must be repeated at such intervals as may be necessary to maintain the required exemption from suffering. No specific time or fixed dose can be prescribed. The sensibility to pain and the power of personal control differ so much in different persons that the surgeon must be guided by the peculiarities of each case. Generally, I have found that a quarter of a grain of morphia placed under the skin, at first every two or three hours, and, as the case progresses, at longer intervals, will secure the necessary quiet and relief from pain.

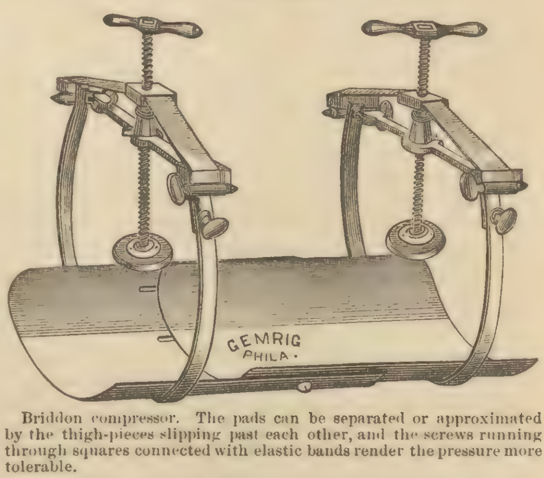
FIG. 388.



Charrière's compressor as modified by Gibbons.

Acupressure.—Another form of instrumental compression is that by means of acupressure pins. These are to be used according to one of the methods laid down under the head of acupressure, and are designed to be temporary in their application. In this respect acupressure is closely allied to the different forms of temporary ligation by tapes, wire, and other materials. The reports of cases treated by this plan are too few to warrant any expression of opinion in its favor.

FIG. 389.



Briddon compressor. The pads can be separated or approximated by the thigh-pieces slipping past each other, and the screws running through squares connected with elastic bands render the pressure more tolerable.

Digital compression.—In 1846, Vanzetti, of Padua, suggested digital compression as a substitute for instrumental pressure, since which time it has gradually grown in popularity, until at present it may be considered an established surgical procedure. The first case treated successfully by this plan alone was one of popliteal aneurism, under the care of Professor Knight, of New Haven.

For several years I have relied almost exclusively on digital compression in the treatment of this disease. By this measure I succeeded in curing seven cases of popliteal aneurism in succession. In one case the result was obtained in eight hours. Vanzetti permanently arrested all pulsation in a popliteal aneurism in four hours, and in Guy's Hospital Reports for 1869, Bryant records a case in which a patient cured himself in four and a half hours by this plan. Boughter* reports an instance of double aneurism of the femoral artery in which he effected a cure of the lower tumor by digital pressure in five hours and a half. Fischer,† in a collection of 188 cases of aneurism of various arteries, found that of 121 cures, 104 were accomplished by digital compression alone. The author, by a more rigid analysis excluding a certain number of failures which he thinks ought not to have been treated by instrumental means, believes that the 104 cures should be subtracted from 138 instead of 188 cases. In 90 instances the popliteal was the vessel affected: of these 55 were cured by digital pressure,—in 20 of them after other modes of treatment had failed. In only one case, and that in an aged man, could death be attributed to digital compression, mortification setting in after the cure of the tumor, probably from extensive disease of the vessels of the extremity. This mode of making pressure may be alternated with instrumental means.

Digital compression possesses certain advantages over other plans, from its being less painful, and more under the intelligence of the operator, and from its applicability to cases of aneurism in localities where instruments cannot conveniently be applied. To carry out this very simple method, it is necessary to have at least six or eight properly-instructed assistants, who can relieve one another every ten or fifteen minutes. It is no ordinary person who can exert the proper degree of pressure for a longer period than fifteen minutes. The force can be applied with the greatest certainty either by placing two fingers of one hand over the vessel and planting upon them the flexed index finger resting against the thumb of the other hand, or by using the two thumbs, one on top of the other. Some recommend placing a bag of shot on top of the fingers, in order to make pressure with the least expenditure of force. The pressure must be made until an assistant, with his hand placed over the aneurism, announces the cessation of pulsation, a test which should be constantly repeated. When the time comes for one assistant to be relieved, his companion must command the artery in like manner before the first removes his fingers. To prevent the surface of the skin from becoming sore, I find nothing answers so good a purpose as dusting it freely with either powdered starch or prepared chalk; and to enable the patient to endure the treatment, it will be requisite in most cases to use hypodermic injections of morphia, as in instrumental compression, though not to the same extent.

The period during which it will be necessary to maintain pressure will depend partly on the ability of the patient to bear the treatment, and partly on the effects produced upon the contents of the sac. The cure, as has been stated, may be perfected in five or six hours, or it may require several days. I generally keep up the compression continuously for thirty-six hours, when, if the desired end is not attained, it is omitted for eight or ten hours, that the patient may have some unbroken rest, after which it is again renewed and persisted in as in the first instance, again stopping for the necessary repose, and resuming treatment after it has been obtained. When the tumor is found to become more solid and the pulsation to diminish sensibly, the surgeon has encouragement to persevere; but if, after the lapse of four or five days, no such signs can be detected, this plan may be abandoned, and, after a sufficient interval of rest for the patient to recover fully from the exhaustion consequent on the pressure, some other method must be adopted.

General compression.—Since the introduction of Esmarch's elastic bandage as a means of effecting bloodless operations, the application of the gum roller has been extended to the treatment of aneurism, and a number of successful cases have been recorded in the different medical periodicals. In two in-

* Philadelphia Medical Times, October, 1871. † Prager Vierteljahresschrift, 1869.

stances of aneurism in which I employed this method, no favorable result was obtained; but, as the event proved, neither was a favorable case for any kind of treatment. The first application of the Esmarch bandage for the cure of aneurism was, I believe, by Dr. Walter Reid. The patient—a male, aged thirty-seven years—was cured in fifty minutes. The tumor was situated on the left popliteal artery.

In applying the bandage, the elastic roller is commenced at the foot and wound firmly up the limb to the aneurism; it is then passed lightly over the tumor until its upper boundary is reached, when it is applied with the same degree of firmness as below. The tubing is next tightly wound about the thigh above the last turns of the bandage, and made fast, after which the latter is removed from the limb. The mode of action combines the Murray and O'Ferrall plans, in which the pressure is complete, is made on both sides of the swelling, and causes stagnation in the contents of the sac. The length of time for which it would be safe to preserve the extremity in this bloodless state has not yet been determined: in one of my cases the blood was not let into the part for one hour and a half. While it would be unjust to speak disparagingly of this measure in view of the limited number of cases treated, it is reasonable to presume that the force with which the blood rushes into the vessels when the cord is removed would seriously disturb the permanency of a recent clot formed in the sac. Repeated trials, however, can alone establish the claims of the elastic bandage to professional confidence.

Flexion.—The treatment by flexion is only a very simple device acting in the same manner as the method by compression. This plan of treating aneurism was introduced to the notice of the profession by Dr. Maunoir, of Geneva, Switzerland, in 1857, though it had been previously employed by an Italian surgeon. At a later date—1859—the successful application of flexion was made by Mr. Ernest Hart, of London. Mr. Spence, of Edinburgh,* after the failure of the ligature in a case of popliteal aneurism, succeeded in curing the disease by forced flexion. This was shortly after the method had been proposed. Mr. Leith Adams† was equally successful in effecting the cure of a popliteal aneurism by flexion in sixty-eight hours, after instrumental pressure had failed. Mr. T. Holmes‡ also cured an aneurism of the popliteal by this plan in three days. These were among the earlier cases treated by forced flexion. This method has been largely practiced both abroad and in this country.

Any one may test for himself the effect of flexion on the circulation by forcibly bending the forearm on the arm, or the leg on the thigh. The acute angle made in the brachial and popliteal arteries will so completely break the force of the blood that the pulsation in the vessels at the wrist and at the ankle will scarcely be perceptible. Herein consists the modus operandi of flexion: the abrupt bend in the artery diminishes the activity of the circulation in the aneurismal sac, and thus favors the formation of fibrinous clots. The application of this method is, from anatomical considerations, necessarily limited, and can be employed to advantage only in cases where the disease is situated at the bend of the arm, at the groin, or in the popliteal space. In treating a case of aneurism by flexion—for example, an aneurism affecting the popliteal vessel—the limb should be bandaged firmly from the foot to the knee, lightly over the knee, and firmly again around the thigh to the groin. The patient being then placed in the recumbent position, on his back in bed, the leg should be flexed upon the thigh, and the thigh upon the abdomen. It will be seen that in this position the pressure is made on both sides of the sac,—below, by the bend at the knee, and above, by the bend at the groin. In order to retain the limb in this position, a roller should be passed round the leg and the pelvis, and a second round the leg, thigh, and pelvis. At the commencement of the treatment the flexion should not be too much forced; but it may be

* Edinburgh Medical Journal, November, 1859, p. 434.
† Medical Times and Gazette, June 26, 1861, p. 82.
‡ British Medical Journal, vol. i., 1868.

increased as the case advances. Though it is said that the patient while under this treatment may be allowed to sit up, or even to move about upon crutches, it is only when at rest and in bed that the full benefit of a quiet circulation is experienced. The time required to effect a cure, in favorable cases, varies from a few hours to two weeks. Some discrimination is necessary in selecting cases of aneurism adapted to this plan of treatment. Indifference to this matter has resulted in serious consequences. In one case the artery appears to have been torn across;* and in a collection of forty-nine cases given by M. Liégois,† treated by this method, seven are said to have perished from rupture of the sac. In aneurisms where the tumor is large or growing rapidly, or where there is evidence of an extensively diseased state of the arterial system, some other method than flexion should be adopted. In many cases of aneurism, especially in very sensitive or irritable constitutions, flexion and compression may be advantageously combined, enabling the patient to endure the treatment with little inconvenience, as the use of the two plans conjointly requires that neither shall be pushed beyond a moderate degree.

The united summary of Fischer's and Liégois's cases of aneurism treated by flexion furnishes the following results: Of 106 cases of popliteal aneurism, 45 were cured and 54 failed. In 29 of the successful ones other methods were used in combination with flexion.

Manipulation.—This process, proposed by the late Sir William Fergusson, consists in compressing or squeezing together the sides of the tumor in such a manner as break up and dislodge fragments of its solid contents and allow them to be swept into the orifice of the vessel leading from the distal side of the sac. By blocking up the vessel in this way, and arresting the current through the aneurism, it was believed by its distinguished originator that the cure would be perfected by the formation of the necessary amount of clot. This plan has not met with much favor, but, on the contrary, has been regarded among surgeons with distrust. When the danger of rupture or of inflammation of the sac is considered, or the probability of mortification and paralysis arising from embolic plugging of the distal vessels, the practice is one which merits unqualified condemnation.

Galvano-Puncture.—It is not surprising that in the extended application of electro-therapeutics to the treatment of surgical disease so powerful an agent should be tested as a curative means in aneurism. The permanent sealing up of vessels by a powerful current of electricity was suggested in 1831 by Pétrequin, and practiced as early as 1832 by Mr. B. Phillips. About the same time this subject attracted the attention of a number of other medical men, among them Mr. Keate. The matter, however, only came prominently before the profession about the year 1845, and then mainly through the results obtained by M. Pétrequin and Dr. Burci, two surgeons, the former a native of France and the latter an Italian. In 1847, the subject was again introduced to professional notice by Guéiraneau, of Poitiers,‡ who, by two applications of galvanism, cured an aneurism of the palmar arch. The method consists in decomposing the blood in an aneurism and thereby causing coagulation, by introducing two or three electro-puncture needles into the sac, and connecting the positive pole of an electro-galvanic battery consisting of twenty or thirty cells for eight or ten minutes in succession with each needle, at the same time keeping the negative pole on the surface of the tumor with a piece of moist rag or sponge interposed. There are those who insist that the positive pole should rest on the skin and the negative be applied to the needles, on the ground, I suppose, that the disengagement of the hydrogen and the oxygen of the blood would take place with less disturbance. The formation of a clot by electro-galvanic decomposition of the blood is an uncertain result, and, when it does follow, the coagulum is so soft and possesses so little cohesiveness that it is prone to break down and open again

* Holmes's System of Surgery, vol. iii. p. 501.
† L'Union Médicale, August 14, 1869.
‡ Archivès Générales de Médecine, November, 1847.

the cavity of the sac to the entrance of blood. In some instances inflammation and sloughing have followed the operation, and the patient has been destroyed from hemorrhage. Whether this condition of the sac was induced by the heat of the needles or by rapid coagulation of the blood, is a question which has not been determined.

Of 23 cases of aneurism treated by electro-galvanism, and collected by Bonnet,* only 2 cures can be legitimately claimed for this method, as in 7 of the 9 reported successes other measures had been simultaneously used. Of the 50 cases of aneurism analyzed by Ciniselli,† 23 are recorded as cured, with 7 deaths. This result is in such striking contrast with that given by Bonnet that it would be wise not to pronounce too hastily on the merits of this plan. The threatening complications which occurred both in the successful and in the unsuccessful cases of Ciniselli's collection may possibly have been due to causes which, on a larger and more careful study of the subject, will prove to be remediable.

Introduction of Substances into the Sac, and also Subcutaneously.—Efforts have been made at various times to induce coagulation of the blood by introducing into the sac certain liquid and solid materials. Monteggia, of Italy, suggested for this purpose the use of solutions of tannic acid and of acetate of lead, substances which possess a solidifying power over the blood. The perchloride of iron, from its property of quickly causing coagulation, is the agent at present almost exclusively used for this purpose. The manner of employing the fluid is that practiced by Pravaz, whose experiments on the effects of this preparation of iron have been chiefly instrumental in introducing it into the list of remedies for the treatment of vascular and other tumors. Twenty drops of a solution of the perchloride of iron should be slowly deposited, according to Dieulafoy, in an aneurism containing three or four ounces of blood, by means of an ordinary hypodermic syringe. While the coagulation is taking place (the work, usually, of eight or ten minutes), and for at least one hour after, the circulation through the sac must be arrested, by pressure, both above and below the tumor, with a twofold object, that of favoring the solidification of the blood, and of preventing any fragments of the concretion from entering the efferent part of the vessel. The operation, if not contra-indicated by the formation of the desired clot, or by the development of inflammatory phenomena in the sac, may be repeated in four or five days, observing the same details as in the first instance. Twice only have I directed the use of this agent, and then in a case of true femoral aneurism, recently under my care, which had proved rebellious to other forms of treatment. Eight drops of the liquid on the first occasion, and twelve on the second application, were introduced, without causing any pain or other inconvenience; but no positive result was noticed from its use. Malgaigne informs us that of eleven cases treated by this method, four died, two recovered, and none who survived escaped without having suffered from some serious complication. Holmes states that of eighteen cases of aneurism in which the injection was used, four proved fatal, the causes of death being gangrene of the sac, and phlebitis. Such a death-rate, and the hazards attending the operation even should the patient escape with his life, justify us in rejecting the method of injecting true aneurism with any of our present known coagulating agents, as one which should be banished from surgical practice.

Ergotin.—Langenbeck conceived the idea of injecting into the subcutaneous tissue, external to the sac, a concentrated preparation of ergotin. It was thought that the property possessed by this drug, of exciting contraction in the muscular walls of the uterus and of the blood-vessels, might in like manner favorably affect the sac of an aneurism. A case of subclavian aneurism is reported, in which sixteen injections of ergotin were made in the course of six weeks, with marked diminution of the swelling, and which was subse-

* Cooper's Surgical Dictionary, vol. i. p. 166.

† Sulla Electropunctura nella Cura degli Aneurismi, 1856. Holmes.

quently cured by digital compression, kept up six hours a day for six days.* Professor Langenbeck gives a case of aneurism of the radial artery, of old standing, cured in eight days by the subcutaneous injection of ergot. If the sac is destitute of muscular fibres, the ergot can exert no contracting influence over the tumor, though it might diminish the flow of blood into the latter, a condition favorable to coagulation, by diminishing the calibre of the afferent and efferent portions of the artery. May not the slight success which has followed the use of this agent have resulted more from inflammatory effects around the sac, caused by the irritation of the liquid in the cellular tissue, than from its physiological action on the organic muscular fibres of the parts?

When ergotin is employed in the treatment of aneurism, the best form of the article is, perhaps, Squibb's fluid extract, each minim of which represents one grain of the ergot. Ten drops of this preparation may be introduced between the skin and the sac, by means of the ordinary hypodermic syringe. The repetition of the injection must be determined by the degree of irritation produced, and by the progress of solidification in the tumor. Oftener than once in two or three days would be improper under the most favorable circumstances.

Introduction of Solid Substances into the Sac.—Attempts have been made, by introducing solid materials into the sac of an aneurism, to secure coagulation of its blood, a practice drawn from the well-known effects of stretching a thread across a vessel, or of the presence of any irregularity encroaching upon its lumen, the foreign body soon becoming covered with a layer of fibrin. The earliest attempt of this kind was made by Moore,† who, in a case of aneurism of the aorta, introduced into the sac, through a delicate canula, twenty-six yards of iron wire. Though the tumor became more solid and the pulsation ceased, the amelioration of the symptoms was only temporary; violent inflammation of the sac was produced, which extended to the pericardium, and the patient died five days after the operation.

Bacelli, of Rome, introduced into an aneurism, through a hollow trocar one-seventeenth of an inch in diameter, a watch-spring, fourteen inches long by one-twenty-fifth of an inch broad. Inflammation and gangrene of the sac followed, and the patient died on the thirtieth day following the operation.

Dr. Richard J. Levis, of this city, in 1876, in a case of aneurism of the subclavian and innominate arteries, which had extended into the thorax, introduced several yards of horse-hair into the sac. A second case of aneurism of the external iliac was treated in a similar manner by the same surgeon. Both cases terminated fatally, the last by inflammation and suppuration of the sac, the patient dying from hemorrhage.

Dr. Maury used the horse-hair in a similar manner, in aneurism of the subclavian artery, in a patient admitted into the Philadelphia Hospital, but with an unsuccessful result. And Dr. Bryant, of London, employed the same material in a case of popliteal aneurism, which was also followed by the death of the patient.

These experiments, to be sure, have been made on the most hopeless forms of aneurism; but it is doubtful if their repetition will yield any more satisfactory results.

Acupuncture Needles.—Attempts have been made to cure aneurism by introducing into the sac in different directions very delicate and highly-polished acupuncture needles. This plan, the suggestion of Velpeau, has rarely been practiced. Dunville relates a case of aneurism of the arch of the aorta, in which nine fine needles, two and a half inches long, were introduced. The patient died in two weeks from hemorrhage. As fourteen inches of fine wire had been previously deposited in the sac, it is difficult to determine to which were to be credited the subsequent inflammation, sloughing, bleeding, and death. In a case of femoral aneurism seated in the groin, after the failure

* Lancet, 1873, vol. ii. p. 750.

† Medico-Chirurgical Transactions, vol. xlvii. p. 129.

of pressure, and the patient being unwilling to allow the application of a ligature to the external iliac artery, I introduced seven acupuncture needles into the tumor, and retained them for twelve hours, but without either evil or good results.

Comparison of Methods.—I do not think it is possible, at present, to establish any fair comparison between the different methods employed for the treatment of aneurism. Many cases which are recorded as cures have been managed by a combination of measures, so that it is impossible to determine which exercised the controlling power. In many others, subjected to pressure, instrumental and otherwise, the appliances have been badly selected, or the assistants unskilled, or insufficient in number; in not a few, the treatment may have been prematurely abandoned, when a little more patience and perseverance would have crowned the work with success,—an objection which cannot be urged against the ligature; and in some instances, doubtless, the plan selected was not well adapted to the cases treated. Enough, however, I think, is known to narrow down the treatment to three plans,—rest, the ligature, and compression. The exceptional cases, such as may be properly regarded as surgical in their character, may become subjects of some of the other forms of treatment already described.

Holmes* has instituted a comparison between the methods by ligature and by compression, as applied to aneurism of the popliteal in the various hospitals of Great Britain, with the following result. Of 44 cases in which the femoral was ligated after compression had failed, 36 recovered and 8 died. Among the recoveries, 4 took place after amputation, and in 1 the aneurism returned. Of 77 cases treated by the ligature at once, 11 died, and the entire number of failures was 15, showing a percentage of 14.3 deaths and 19.48 failures. Of the 124 cases treated by compression, 66 were cured at once; in 44 of the others the ligature was applied with success in 31, making the entire number of successful cases 97, and of unsuccessful 27. Of these last only 13 died, 5 after amputation without previous ligature, and 8 after ligature, the death-rate being 10.5, and the rate of failure 21.8. This exhibits a slight percentage of deaths in favor of compression. The statistics of Holmes bring out another fact, namely, that ligature after compression is more fatal than when done at once, the rate of mortality when the ligature was applied after pressure had failed having been 29.54 per cent., while it was only 19.48 per cent. when the ligature was applied without any previous treatment.

Under any circumstances, the treatment of spontaneous aneurism is attended with much uncertainty as to the final issue. The same considerations which govern the surgeon in undertaking any grave operation should have equal weight when applied to cases of aneurism. Where the kidneys are diseased, or the patient is much exhausted by prolonged suffering, and where there is extensive disease of the heart, or a second aneurism is present, affecting the abdominal or the thoracic aorta, any operation is of doubtful propriety, and most of all the ligature. One thing, I think, will be apparent on a careful examination of this subject, that an aneurismal sac is very sensitive to irritants of any kind, and that therefore all methods which consist in subjecting an aneurism to the presence of foreign bodies, in order to secure coagulation of its contents, are dangerous procedures. In all aneurisms which come properly within the scope of surgical treatment, pressure, in some one or in several of its forms,—including flexion as one of these,—should be first and fairly tested, always preceded by preparatory measures, such as entire quiet in the recumbent position, a properly-regulated diet, and the exhibition of heart-sedatives, subjects which have been already noticed. If, after a patient trial, these measures fail, and if there be no contra-indicating circumstances of a constitutional or local character, resort may be had to the ligature, allowing, however, before making the operation, ample time, when the case is not urgent, for the soft parts to recover from the effects of the pressure,

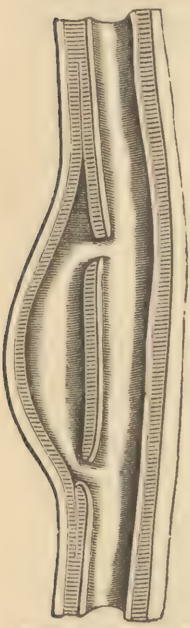
* Lancet, May 1, 1875, p. 598.

and for the general system to overcome the exhaustion consequent on the previous treatment.

False Aneurism.—Under false aneurism I include all collections of blood which communicate with the cavity of an artery, but which are not circumscribed by a sac derived from the walls of the vessel. Under this head come dissecting aneurism, traumatic aneurism, and true aneurism in which the sac has ruptured and its blood escaped into the surrounding parts.

Dissecting Aneurism.—The term was first used by Laennec, though the disease had been previously described by Morgagni and others. In this form of aneurism the tunica intima yields, and the blood finds its way into the tunica media,—as shown, first, by Dr. Pennock,—and may become diffused for a considerable distance up and down the vessel, separating the layers of the middle coat from each other; or, if the blood passes beyond the limits of this coat, it may spread itself through the connective tissue of the adventitious tunic. Mr. Erichsen describes a variety of dissecting aneurism in which the blood, after breaking through the intima and rending asunder the layer of the middle coat, again enters the cavity of the vessel at a point some distance from the first opening. (Fig. 390.) Mr. Shekelton,* as early as 1822, described a similar form of the disease. In one case, recorded by Dr. Henderson,† the upper opening into the coats of the aorta took place near to the left subclavian and the lower opening into the left common iliac arteries. Dissecting aneurism (Fig. 391) is limited for the most part to the aorta, and most frequently to its arch, particularly the ascending portion of the latter. In 10 out of 19 cases analyzed by Dr. Peacock,‡ it involved the first part of the vessel. The innominate artery may participate in the aneurism by continuity of structure. The disease affects both males and females, though the latter suffer most frequently. Of 15 cases collected by Dr. Peacock, and 21 by Dr. Crisp, making together 36 cases in which the sex was given, 17 were males and 19 females. The ages of the patients varied from twenty-four to eighty-four years. There are no symptoms which reveal the existence of this form of aneurism, and its termination is usually by rupture, in which the blood, when the ascending part of the aorta is involved, escapes into the pericardium.

Fig. 390.



Dissecting aneurism, in which the blood, after leaving the vessel, passes some distance between its walls and again enters its canal.—Holmes.

Fig. 391.

Dissecting aneurism of the aorta extending the entire length of the vessel.—From a specimen in the University of Pennsylvania, presented by Dr. Pennock.

Shekelton§ alludes to two cases found in bodies used for dissection, in which a partially spontaneous cure had occurred. In one, the anterior part

* Dublin Hospital Reports, vol. iii.
† London and Edinburgh Medical Journal, July, 1843.
‡ Edinburgh Medical and Surgical Journal, vol. ix., 1843.
§ Hayden, Diseases of the Heart and Aorta, Part II. p. 1219.

of the abdominal aorta was tunneled, and the canal, which was lined with a deposition of fibrin, opened by two orifices, one into each of the common iliacs. In the second, the walls of the left primitive iliac were separated, and through this the blood passed to the limbs, while the circulation in the pelvis was carried on through the usual channel of the internal iliac.

Traumatic Aneurism.—This is another form of false aneurism, and may be produced in various ways: 1, by punctured wounds; 2, by gunshot wounds, in which the vessel may be immediately opened, or, if the artery be only grazed, this may not take place for several days, or until the detachment of a slough; 3, by the sharp fragment of a bone, as sometimes occurs in fractures; 4, by forcible attempts to reduce old luxations; 5, by overstrain in which an artery gives way; and, 6, by the ulceration or the sloughing of a true aneurismal sac. There are two forms of traumatic aneurism, the *diffuse* and the *circumscribed.* Both may exist with or without an external wound. Between traumatic and spontaneous aneurisms there is this important distinction, that in the first there is usually before the accident a sound condition of the injured vessel, whereas in the last the artery is diseased.

Diffused traumatic aneurism.—When an artery is wounded by a stab, the blood escapes through the external wound, but may cease to flow, either in consequence of the resistance offered by the tissues, or, more generally, from the pressure which is immediately applied. The wound, being closed and bandaged, unites, and to a careless spectator all may appear well. The blood, however, continues to escape from the opening in the artery, diffusing itself through the surrounding parts, slowly if the lesion in the vessel is small and the contiguous structures are compactly bound together by dense connective tissues or strong aponeuroses, or rapidly when the opening is large or the vessel lies in regions like the axilla, the popliteal, or the gluteal, where the anatomical components are loose and movable. The progress of such an extravasation is retarded by the condensation and the inflammatory adhesion of the surrounding structures, and also by coagula of blood and masses of fibrin.

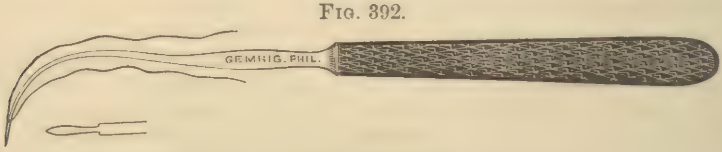
Symptoms.—The signs of this accident are the presence of a soft swelling, which may have been preceded by a copious external hemorrhage which ceased on the application of a firm compress; or, where there is no obstacle to the escape of blood externally, as in a direct wound, there may be no swelling discoverable until after the wound has united and the compresses used in dressing have been removed. As the tumor enlarges, its arterial origin will be disclosed by the presence of pulsation, attended by a blowing or a purring sound, and the absence of the pulse in the vessel below. The size of the aneurism will be determined by its locality. In the axilla, where the tissues are loose and its boundaries very movable, or at the root of the neck, it may attain a very great bulk, whereas in the palm of the hand or at the bend of the arm it may, in consequence of the strength and resistance of the fascia, grow very slowly. The tendency of diffuse aneurism is to extend, stretching and separating the anatomical components of the parts in which it is situated, and filling the space with soft clots, until inflammation, abscess, or sloughing takes place, when, an external opening being formed, the patient is liable to perish from hemorrhage.

Treatment.—All temporizing expedients in cases of a growing, diffuse aneurism are hazardous. Occasionally a case is cured by compression or by flexion; but the success of such measures is too uncertain to justify any long delay in adopting a more radical course. The safety of the patient depends upon exposing the divided extremities of the injured vessel and securing them with ligatures. In deeply-situated arteries, such as the posterior tibial in the calf of the leg, or the gluteal in the buttock, this is not always an easy task. It is always desirable to tie the vessel as near the seat of the original injury as possible, rather than to ligate the trunk at a distant point. When the latter is practiced, the surgeon has no security against a renewal of the bleeding from the distal side of the aneurism.

In performing the operation, the circulation must be controlled by first applying a tourniquet to the artery above the tumor. An incision should next be made into the swelling its entire length, and all the coagula, liquid blood, and necrosed tissue belonging to the extravasation turned out. A careful search must now be made for the wound in the artery. Should it have been cut entirely across, greater difficulty, in consequence of its retraction, will be experienced in finding the vessel than would have been the case if its continuity had not been entirely destroyed.

After getting rid of all foreign accumulations, and washing out the wound well with injections of a solution of the permanganate of potash, in order to remove everything which tends to obscure the examination, the surgeon, if he fails to identify the artery, may have the tourniquet or other pressure slowly relaxed, at the same time keeping his eye intently directed to the wound, that he may detect the point where the blood begins to make its appearance. Should the hemorrhage commence, he may in this way identify the locality of the vessel. Sometimes the same end can be accomplished by carefully exploring with the point of a probe the region in which the artery should be found, the presence of which may be disclosed by the instrument entering its orifice. It may be that a false aneurism occupies a position not admitting of the use of the tourniquet. In such a case the operator must proceed with great caution. He should first make an opening into the swelling just sufficient to admit the finger of one of the hands, so as to prevent the external escape of blood, while he conducts the digit to a point which he believes to be the orifice of the artery; the external wound should be slowly enlarged, frequently stopping to ascertain if the finger is rightly placed, a fact which will be known by the absence of bleeding, and changing it from point to point, should the hemorrhage occur, until the right one has been reached, after which he may boldly ext nd the incisions to the utmost bounds of the tumor, scrape away the clots, and cautiously dissect down upon the vessel above the finger, and surround it with a ligature. I have found the awl described by Professor Horner (Fig. 392) admirably suited for applying the thread to the artery under such cir-

FIG. 392.



Horner's awl, with the ligature looped over its extremity.

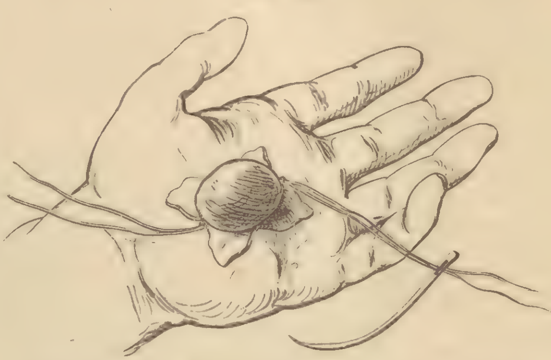
cumstances. The instrument has a short curve, and has a shoulder, instead of an eye, a short distance from its extremity, the latter being awl-shaped. The needle is made very strong, and is mounted on a stout handle. In using it, a thread is looped, passed over the point, and tightened above the shoulder. It is then dipped into the tissues on one side of the artery to which the ligature is to be applied, and brought out on the other side; the thread is then hooked over the point with a tenaculum, after which the instrument can be withdrawn and the cord tied. After the cardiac end of the vessel has been secured, and the bleeding thus stopped, the distal end must be searched for and subjected to a similar treatment. If the surgeon, notwithstanding the best-directed efforts, fails to ligate the artery,—an exceptional occurre ce, however,—he must rely upon properly-constructed compresses rendered . tiseptic by a solution of carbolic acid, or on the actual cautery.

The wound after the operation for diffused aneurism cannot be united like an ordinary incised one, but must be left to granulate, as in wounds of the open class. The greatest attention must be given to the dressing. The parts having been first washed out with a solution of the permanganate of potash, and afterwards well sprayed with carbolic acid, a drainage-tube should be introduced, and the opening lightly packed with carbolized lint or very soft

oakum. When the suppuration begins to be free, the dressing, in all its details, must be repeated morning and evening. The diet, and the administration of tonics and stimulants, must be determined by the constitutional state of the patient.

False circumscribed aneurism is one in which the escape of the blood from the wounded artery is followed by inflammatory infiltration of the surrounding parts and the conversion of this transudation into a circumscribing wall of connective tissue. In the commencement of false aneurism there is usually no difference between the diffuse and the circumscribed variety, the point of distinction consisting in the investing wall of lymph. The tumor is frequently seen at the bend of the arm, in the palm of the hand (Fig. 393), and near the wrist (Fig. 394) where the radial artery is superficial and exposed to injury. Venesection, a fragment of a percussion-cap, the point of a knife, or a particle of glass, most commonly cause the accident.

FIG. 393.



Traumatic (circumscribed) aneurism in the palm of the hand, caused by a fragment of percussion-cap. The skin has been turned off, and a double ligature passed beneath, preparatory to its strangulation.

When the aneurism is the result of a small puncture, the circumscribing sac is often formed in part by the dense connective tissue constituting the sheath of the artery. This is more especially the case where the aneurismal swelling, in consequence of pressure being immediately applied to the bleeding orifice, does not appear until several days after the accident. Under such circumstances the opening in the vessel has been partially repaired, but the union does not possess sufficient strength to withstand the blood-pressure, and either gives or becomes stretched and thickened. The formation of a sac transforms the condition of the tumor very much into that of a true aneurism, and the same concentric deposition of fibrin takes place as in the latter.

FIG. 394.

Traumatic (circumscribed) aneurism of the radial artery, produced by the point of a penknife.

SYMPTOMS.—The swelling is of less magnitude than in the diffuse form of the disease, is somewhat sharply defined, possesses considerable resistance, pulsates synchronously with the contraction of the left ventricle of the heart, and yields a distinct bruit to the ear. Pressure upon the artery above arrests pulsation in the tumor and causes it to diminish sensibly in size.

TREATMENT.—As circumscribed aneurism is, anatomically, closely allied to true aneurism, it should be treated first by compression. As the tumor is generally found in a superficial situation, the artery can be very easily controlled, and the pressure should be applied a short distance above the sac. Flexion can often be advantageously used in conjunction with pressure, either digital or instrumental. When compression fails, resort must be had to the

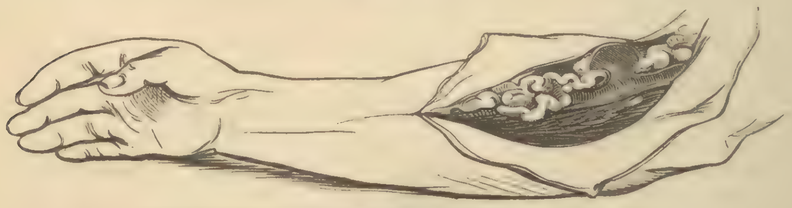
ligature. After providing for the possible occurrence of hemorrhage by placing a tourniquet loosely upon the arm, or detailing an assistant to make digital compression if necessary over the artery leading to the aneurism, an incision should be made over the tumor, commencing a short distance above and terminating a like distance below. The skin should be carefully dissected off on each side, and the vessel exposed and tied, both on the cardiac and on the distal side of the swelling, with the animal thread, after which the skin can be replaced and the flaps stitched together with a few points of the interrupted suture. Some writers direct the laying open of the sac and the removal of its contents at the same time that the vessel is tied. This procedure is entirely uncalled for, and I never adopt it in practice. After the artery is ligated, the coagulum in the aneurism is gradually absorbed, and the wound in the soft parts unites by quick union, whereas if the sac is laid open the cavity must suppurate and the chasm be repaired by a slower process of granulation.

When the aneurism is connected with the radial artery near the wrist, it will be necessary to tie both the superficial volar and the radial vessels on the distal side, to interrupt completely the circulation in the sac.

When the tumor is seated in the hand and is connected with the superficial palmar arch, I am in the habit, after dissecting the skin from the swelling, of passing a needle, armed with a strong double ligature, beneath its base and strangulating each half separately. After the mass sloughs off, the skin can be still used to cover up the part.

Arterio-venous Aneurism.—Another form of false aneurism is that which is commonly known as the arterio-venous. Of this there are two varieties,—one in which the walls of an artery and of a vein are closely united by inflammatory adhesion and a direct communication exists between the two, —*direct aneurism*,—generally called *aneurismal varix* (Fig. 395); and one

FIG. 395.



Direct aneurism, or aneurismal varix, exposed by a vertical section.

in which a sac is formed out of the connective tissue between an artery and a contiguous vein, separating the two some distance apart, and through which the blood passes from the artery before entering the vein: this is an *intermediate* or *varicose aneurism*. (Fig. 396.) These aneurisms are generally situated at the bend of the arm, and, with few exceptions, are of traumatic origin; though they may also arise spontaneously. When traumatic, they are usually caused in the operation of venesection by the blade of the lancet passing through the median basilic vein and the bicipital aponeurosis and puncturing the brachial artery beneath. Goupil—a French surgeon—states that in fifty-seven cases the accident occurred thirty-one times from venesection. The infrequency of this aneurism at present is largely due to the disuse of bleeding

FIG. 396.

Intermediate or varicose aneurism; the sac lying between the median basilic vein and the brachial artery. After Sir Charles Bell.

as a remedy in disease. The affection, however, is not confined to the artery and the veins of the arm. It has been met with between the aorta and the ascending vena cava, between the femoral artery and its accompanying vein, and between the carotid artery and the internal jugular vein. In one case an arterio-venous aneurism was seen in the vessels of the popliteal nerve.* I have seen the direct variety follow an amputation of the thigh, in which the bruised artery and vein had been included in the same ligature, the channels of the two vessels becoming continuous during the separation of the ligature. The effect of this interchange of blood upon the vessels is quite marked. The artery, under such circumstances, gives more blood to, than it receives from, the vein. The latter, as well as its branches, becomes dilated, tortuous, and thickened for a considerable distance above and below the swelling, and, receiving with the arterial blood the direct force of the heart's action, beats synchronously with the contraction of the left ventricle. The artery, having much of its blood turned into the new channel, becomes contracted below, so that its pulsation is much diminished in strength, and is often quite indistinct on the distal side of the tumor. Above the point of communication its walls are sometimes dilated and thinned. In a case of arterio-venous aneurism which was brought into the University Hospital, and which subsequently died from gangrene, the deep-seated veins participated more in the dilatation than did the subcutaneous ones.

Symptoms.—There are symptoms common to both varieties of arterio-venous aneurism. In each there is generally the history of a previous wound; in each there is a distinct blue, pulsating, compressible tumor, which can be emptied by pressure on the artery above, and to a great extent by pressure upon the swelling alone; in each, also, there are sounds recognizable by the ear, which are blowing or hissing in their character, or are like the sound caused by a fly on a pane of glass, or—as Porter designates it—by a fly in a paper bag. On a closer examination of the two forms of the disease, however, certain differences can be detected; for example, in the mediate variety there is a more decided tremor or fremitus propagated over the tumor, and the sounds are more continuous than in the intermediate form. In the latter, the tumor, which at first was soft and compressible, becomes more firm in consequence of the fibrinous concretion which forms in the sac, and the blowing sound is more pronounced than in the mediate form.

The intermediate variety can be often recognized by compressing the venous swelling until it is emptied, when a second tumor—the interposed sac—can be felt beneath, which in turn can also be diminished by pressure.

The progress of arterio-venous aneurism is usually very slow. Cases are recorded in which no perceptible increase has been noted for eighteen, twenty, and even thirty years. When the tumor does enlarge, much evil may result from the pressure. The obstruction to the circulation will cause œdema of the limb, loss of power in the arm by encroaching upon the median nerve, loss of temperature, ulceration or sloughing of the sac or the vein, followed by hemorrhage and, in some instances, by mortification of the limb.

Treatment.—If the injury can be recognized at the time of its reception, there is little doubt that by applying a firm compress over the vessels at the bend of the arm—when the wound has been inflicted in this location—and then arresting the circulation through the main artery by means of compression and flexion, the occurrence of arterio-venous aneurism might be almost prevented. This treatment, however, will be the proper one at any stage of the disease. Should it fail, and the aneurism cause no particular inconvenience or disability and show no tendency to material increase, it will be best to avoid any interference, as operations for the cure of this affection have often proved fatal. When the disease, by its growth, demands that some radical measure shall be undertaken for its cure, that which promises the best result is to dissect the skin carefully from the tumor, and, ex-

* Medico-Chirurgical Transactions, vol. xx.

posing the brachial artery, to tie it above and below, close to the aneurism, with the catgut thread. When feasible, a third ligature should be carried round the communication between the artery and the vein, so that in the event of an anastomosing branch communicating with the artery intermediate to the two ligatures, the blood shall be prevented from entering the vein. The difficulties of the operation should not be under-estimated, as the inflammatory changes in the parts will often render it difficult to discover the communication between the artery and the vein, or readily to distinguish—in consequence of the pulsation—the two sets of vessels from each other. There need be no opening of either the dilated vein or the sac beneath, when such exists. The integument should be replaced and the wound dressed as after ordinary operations, by bringing its edges together with stitches or with adhesive straps, and, after applying a pledget wet with water or moistened with carbolic acid and sweet oil, a roller should be applied and the part placed in an easy position, on a pillow.

ANEURISM OF SPECIAL VESSELS.

Thoracic and Cervical Aneurism.

Aneurism of the Thoracic Aorta.—The thoracic aorta, intrenched within the walls of the thorax, is beyond the reach of surgical treatment: still, much may be done to retard the progress of an aneurism of this vessel and contribute to the comfort of the patient. Men are more subject to aortic aneurism than women.

The thoracic aorta exceeds all other vessels in the frequency with which it is attacked with aneurism. Of 915 cases of the disease embraced in the tables of Mr. Crisp, 382 involved the thoracic aorta. Myers found that this part of the aorta suffered from aneurism 94 times in 109 cases. The ascending and transverse portions of the vessel are most frequently affected. Of the 109 instances of aneurism analyzed by the last-named author, 37 were in the ascending, 38 in the transverse, and 19 in the descending part of the arch. This is in all probability due to the fact that the ascending and transverse portions of the vessel sustain the severest strain of the heart's stroke. Aneurism of the arch of the aorta is not inconsistent with the existence of a perfectly-sound heart; though Mr. Walshe thinks the disease tends to produce hypertrophy of this organ.

Symptoms.—These may be arranged under two heads,—the *rational* and the *physical*.

The rational signs are numerous and varied, and are due to the effects of pressure upon the contiguous parts. Hence the prominence of these signs will depend on the magnitude and form of the tumor, and upon the direction in which it grows.

Large and sacculated aneurisms give rise to greater functional disturbances than small and fusiform ones; and those which develop in the direction of the neck cause more urgent and threatening symptoms than those which enlarge in the direction of the chest.

Pain is both an early and a late symptom of intra-thoracic aneurism: it is localized, is usually of a dull, deep-seated nature, and is experienced behind the sternum or between the shoulders. The severity of the pain is increased on taking any active exercise, or by any cause which accelerates the circulation. Besides this fixed pain, the patient is attacked, after a time, with another and a more acute kind of suffering, pains which are darting, intermittent, or neuralgic in their character. These extend into the neck and head, generally on the left side, corresponding to the branches of the cervical nerves; sometimes the pain encircles the upper part of the chest, in the direction of the intercostal nerves; and often it shoots down the side of the thorax, and along the inner surface of the arm, following the distribution of the intercosto-humeral nerve. When the aneurism encroaches upon the ver-

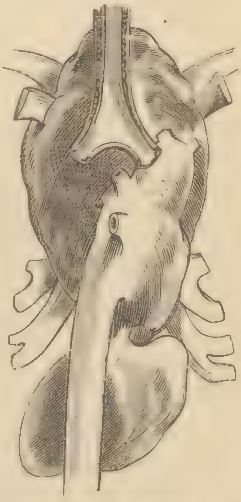
tebræ, sternum, ribs, or other portions of the bony walls of the chest, the pain experienced is of a hot, boring, and gnawing character.

Dyspnœa.—This is a very common and a very distressing symptom, and is caused by the aneurismal tumor pressing on the bronchial or the tracheal tube, or even upon the lung itself. Often it is a reflex result from pressure upon the recurrent laryngeal or the pneumogastric nerve, and is attended with a croupy or stridulous respiration, feeble voice, cough, and mucous expectoration. The aphonia which so often accompanies aggravated forms of the aneurism may be caused either by laryngeal congestion from venous obstruction, or by paralysis of the vocal cords on one side from pressure on the recurrent laryngeal nerve. The same cause which interferes with the function of the recurrent laryngeal nerve may affect the sympathetic when it passes into the thorax, and produce the symptom first noticed by Dr. Hare in 1838,* namely, contraction of the pupil of the eye.

Difficult deglutition is another effect of pressure, and results from compression of the œsophagus. The latter tube, being behind the bronchi, is so deeply placed that the tumor will have acquired considerable bulk before this symptom is experienced, except in cases in which the sac is formed on the descending part of the aorta, where the artery is closely related to the œsophagus. Under such circumstances, dysphagia may appear before the aneurism is large, and in the early stage of the disease.

Venous congestion.—Aneurism of the arch of the aorta extending up into the neck may materially interfere with the venous circulation. (Fig. 397.) The transverse innominate, internal jugular, subclavian, and descending cava veins are all liable to pressure from this cause; and when the obstruction is very marked, it will be followed by turgescence of the veins of the neck, with lividity of the face, a sense of fullness in the head, and œdema of the arm. When the pressure extends to the azygos or the hemiazygos vein, a dilated condition of the venous trunks on the front of the chest is likely to follow. In addition to these signs, we may have the aneurism exceeding the limits of the thorax, appearing in the neck and filling up the supra-sternal fossa. When the tumor takes this direction, the branches of the aorta may be so pressed or distorted as materially to weaken their pulsation.

Fig. 397.



Aneurism of the arch of the aorta rising into the neck,—posterior view.

Physical Signs.—When the aneurism is in contact with the anterior walls of the thorax, there will be a corresponding area in which the percussion-sounds are dull, though, if the tumor subsequently change the direction of its growth and recede from the surface, the dull sound may be replaced by a resonant one. When the hand is laid upon that portion of the surface of the chest which corresponds to the position of the arch of the aorta, a vibratory sound, tremor, or fremitus will often be experienced. The thrill and pulsation which characterize aneurism elsewhere are rarely heard and felt when the disease is intra-thoracic; though when the tumor rises into the neck or presses against the walls of the chest, these signs are readily detectable. There is a singular absence of uniformity in the auscultation-sounds. A double impulse and double sound may exist with or without a systolic murmur; a double murmur may be present without either impulse or sound; and it is possible not to be able to recognize impulse, sound, or murmur. Occasionally a case will be met with in which the systolic murmur is loud and blowing.

Diagnosis.—The absence of any distinctive physical signs, and the fact that the pressure-effects which have been described may attend growing

* Medical Gazette, 1838.

tumors situated in the upper part of the thorax, render the diagnosis of intra-thoracic aneurism one of considerable uncertainty. I have seen cases of malignant disease springing from the bronchial glands in which every symptom belonging to aneurism of the arch of the aorta was present. Abscess, especially when in the posterior mediastinum, will also give rise to symptoms which simulate strongly those of aneurism within the chest: and the same may be said, to a certain extent, of cardiac hypertrophy and of pulsating empyema.

Writers have attempted to differentiate these diseases; but the lines of distinction, except in typical or pronounced examples, are too faint to command an assuring confidence. The surgeon must rest his diagnosis on a comprehensive consideration of all the symptoms which are developed in the progress of a case.

Duration and Termination.—The duration of intra-thoracic aneurism rarely exceeds one year, but is determined, of course, by the rapidity of growth and the parts subjected to pressure. Walshe never witnessed a case in which the patient lived over thirty-eight months. Dr. Williams mentions* one instance of a person who had been suffering for thirty years with an aneurism of the arch of the aorta. Intra-thoracic aneurism may terminate in different ways. The sac may become adherent to the trachea, to the bronchi, or to the œsophagus, and, by ulceration, open into these tubes, destroying the patient by hemorrhage. It may also open into the pulmonary artery or into the cava. When the ascending portion of the aorta is involved, the tumor frequently bursts into the pericardium. Instances are not rare in which the walls of the thorax disappear by absorption, the tumor passing through the opening thus made, and being covered only by the soft parts. In some cases life is destroyed by asphyxia, or the individual may die, worn out by prolonged functional disturbance.

Treatment.—The treatment best adapted to thoracic aneurism is one which will lessen the action of the heart; and this end is most satisfactorily attained by rest, a carefully-regulated diet, and, where there is severe dyspnœa, by the abstraction of blood and the exhibition of anodynes. Mr. Tufnell, by enforcing complete rest and a systematic diet, has succeeded in curing eight cases, six of these being aneurism of the abdominal aorta and two of the arch of the aorta.† He confines the patient to the horizontal posture from eight to thirteen weeks, allowing a change of position only to the side or upon the face, and that change to be made very slowly. The bowels and the bladder are emptied without rising, the mattress having the conveniences of a fracture-bed. The diet is arranged as follows: for breakfast, two ounces of white bread and butter, with two ounces of cocoa or milk; for dinner, three ounces of meat, with three ounces of potatoes or bread, and four ounces of water or light claret; for supper, two ounces of bread and butter, and two ounces of milk and tea. This diet is modified somewhat when required by the failing strength of the patient. Opium is administered in sufficient quantity to relieve pain.

The iodide of potash has enjoyed considerable reputation in the treatment of aneurism. The remedy, according to Walshe, was first recommended in 1859, by Bouillaud, and in 1869 was prominently brought before the profession by Dr. George W. Balfour.‡ This physician reported a number of cases of aneurism successfully treated with this agent, one of which was intra-thoracic. Duckworth§ has also succeeded in curing an aneurism of the arch of the aorta with this remedy. The dose of the iodide of potash administered ranged from thirty to ninety grains daily for months. There can be little doubt that this salt exercises some sedative influence over the action of the heart; but whether this property or the prolonged rest was the curative

* British Medical Journal, May 12, 1876; quoted from Hayden.

† Tufnell, Treatment of Internal Aneurism, 1864; also Medico-Chirurgical Transactions, vol. xxxix., Second Series, 1874; also Transactions of the International Medical Congress, Phila., 1876, p. 571.

‡ Edinburgh Medical Journal, 1869.

§ British Medical Journal, August 23, 1873.

factor in the cases which have been recorded is still an unanswered question. That such aneurisms occasionally undergo spontaneous cure is also noteworthy. A case of this kind is recorded in the "Lancet,"* in which an aortic sac solidified while at the same time the left subclavian and left common carotid arteries were obliterated. Where medical means have failed to arrest thoracic aneurism, there have not been wanting those who were bold enough to attack the disease by surgical measures. Ciniselli applied electro-puncture in 23 cases of intra-thoracic aneurism, 5 of which were reported as cures, and only 1 of the number died from the effects of the operation, in consequence of gangrene attacking the place of puncture. The cases most favorable for this treatment are said to be those in which the transverse portion of the arch of the aorta is involved, where the opening between the vessel and the sac is small, and when the disease is extending along the vessel to the neck. The practice of Ciniselli has been imitated by Anderson, Charlton-Bastian, and others. In well-selected cases, the possibility of curing aortic aneurism by distal ligature of the left carotid receives considerable support, not only from the cases of Tillanus and Rigen, but also from those of Wright of Montreal,† Greenhow,‡ and Heath. In Heath's case, an aneurismal sac of the arch of the aorta had undergone almost a cure by the spontaneous obliteration of the left carotid and left subclavian arteries. In 1869, Cockle discussed with much ability the propriety of extending distal ligation to cases of aortic aneurism.§ Heath has in two instances ligated the left carotid artery for aneurism of the ascending and transverse portions of the arch of the aorta. His first case was relieved for a period of four years, when the swelling again made its appearance.

On the 10th of March, 1876, Holmes‖ applied a ligature to the left carotid artery in a case of aneurism affecting the arch of the aorta, in a young woman twenty-one years of age. This patient, though not cured, was much improved, both as regarded the growth of the tumor and her general symptoms. It is worthy of notice that in this case the woman had been six months under the "rest" treatment, and had also received hypodermic injections of ergotin previous to the operation.

Moore and Murchison introduced a quantity of iron wire into the sac of an intra-thoracic aneurism: the patient died five days after the operation. I am not disposed to fix the bounds of surgical venture in a work so noble and eminently humane as that of saving or prolonging the life of a fellow-being; but with a full knowledge of all that has been achieved in this direction for the cure of aneurism of the arch of the aorta, I may assume to say that the cases which justify a resort to electro-puncture or to the ligature are very limited in number, while the desperate attempt at solidification by the introduction of any foreign substance yet known into the sac of such an aneurism is a rash, if not a criminal, trifling with human life. The operation of opening the larynx or the trachea, in order to relieve the distressing symptoms of spasm of the glottis and the sense of suffocation which so often attend intra-thoracic aneurism, is of doubtful propriety, as it is impossible, in most instances, to refer the dyspnœa to its proper source. The laryngoscope might furnish valuable assistance in discovering the part played by the recurrent laryngeal nerve in producing the obstruction to the admission of air. Except when the impeded respiration arises from a cause of this kind, an opening into the air-passage could be productive of no benefit.

Aneurism of the Innominate Artery.

The anatomical relations of the innominate and the arch of the aorta are such that it is often difficult, and sometimes altogether impossible, to distinguish

* Lancet, 1876, vol. i. p. 426.
† Ibid., 1872, vol. ii. p. 70.
‡ Clinical Society's Transactions, London, 1876, vol. ix.
§ Lancet, March 27 and April 10, 1869.
‖ Clinical Society's Transactions, London, 1876, vol. ix. p. 114.

aneurism of the former from that of the latter vessel. Not unfrequently both are simultaneously affected, or the dilatation may extend from the aorta to the innominate, until the two arteries form a common pouch. The subclavian and the primitive carotid vessels may likewise participate in aneurism of the innominate trunk. It occurs, according to the tables of Crisp and of Lisfranc, something less than five times in every hundred cases of the disease.

Symptoms.—Placed as the vessel is, behind the left sterno-clavicular junction, aneurism of the innominate artery often begins as a small, round or oval, pulsating tumor, which may be seen and felt in this region, or a little to the inner side in the supra-sternal fossa. If the sac continues to grow in this direction, the sterno-hyoid, sterno-thyroid, and sterno-cleido-mastoid muscles will be pushed forward, forming a considerable swelling at the root of the neck. Should the sac be developed from the thoracic surface of the vessel, no tumor whatever may be detectable in the neck. The percussion-sounds over the region of the tumor will be dull, and the auscultation-sounds may be in all respects similar to those of the heart. The impulse communicated through the overlying parts will usually be strong, and the aneurismal bruit may or may not be present.

Effects of Pressure.—These may be divided into those which affect the circulation, arterial and venous; those which affect the nerves; those which affect deglutition and respiration; and those which affect the osseous and cartilaginous structures of the thorax. In consequence of the impediment to the flow of the blood through the subclavian artery, the right radial pulse is generally weak, sometimes beating discordantly with the action of the heart, and occasionally hardly distinguishable at the wrist. From the same cause the circulation in the carotid branch of the innominate may be much lessened in force. When the tumor grows into the chest, both the aorta and the heart may be subjected to displacement, which may account for some of the eccentric phenomena witnessed in the irregular action of the heart.

The relation of the descending cava and of the transverse, subclavian, and internal jugular veins to the innominate artery is such that these vessels cannot long escape the effects of pressure. When the blood-current becomes interrupted through the deep jugular and transverse veins, both of which lie in front of the artery, between it and the walls of the chest, the obstruction will be announced by enlargement of the superficial veins of the neck, by lividity of the lips, by a puffy condition of the eyelids, and, in extreme cases, by œdema of the face, and by projection of the eyeballs in consequence of the intraorbital effusion. In like manner the left arm may become œdematous, from embarrassment of the circulation through the subclavian. Lying within the pressure-sphere of an enlarging innominate aneurism are a number of nerves of great functional importance. In front of the artery are the pneumogastric and cardiac branches of the sympathetic; behind, the recurrent laryngeal and the sympathetic; to the outer side, the phrenic; and still more externally, the brachial cords and branches of the cervical plexus.

Among the rarer structural changes induced by aneurism of the innominate is a protrusion of the bony walls at the summit of the thorax. The sternum, clavicle, and upper two ribs, with their cartilages, may be carried forward, and in some instances may undergo a partial absorption.

Symptoms.—Pain is an early symptom of innominate aneurism. It may arise from irritation of the branches of the cervical or brachial nerves, and is generally constant and dull in the region of the tumor, but frequently paroxysmal, extending up the side of the neck and face, over the front and side of the chest, over the scapula, and down the right arm. Cough is rarely a prominent symptom in innominate aneurism: when present, it is due to irritation of the recurrent laryngeal nerve. Contraction of the pupil, a symptom of very frequent occurrence, must arise from pressure of the sac upon the sympathetic.

Difficult breathing is another symptom. It may result from direct pressure —generally lateral—against the trachea, or it may be a reflex effect from the

encroachment of the tumor upon the recurrent laryngeal nerve. In such an event there will be paresis of the vocal membrane; the voice may be deep and hoarse, or it may be high-pitched; at other times the patient may not be able to speak above a whisper; a brassy, stridulous cough, either dry or attended by the secretion of a frothy, laryngeal mucus, is also sometimes present. In aggravated cases of dyspnœa, the wild, frightened stare, and the extreme agitation produced by the struggle for breath, are extremely distressing to witness.

When the dyspnœa is marked, there will be more or less difficulty in deglutition, the œsophagus participating in the compression.

Diagnosis.—Aneurisms of the innominate and of the arch of the aorta are frequently confounded, especially when examined at an advanced period in their history. Considered from an anatomical stand-point, there should be well-defined phenomenal differences. These have been well brought out in exhaustive detail by Holland* in a careful analysis of forty-five cases of innominate aneurism, which is well worthy of a patient perusal. Let it be remembered that the position of the arch of the aorta is wholly thoracic, median, and to the left of the spine, while that of the innominate is both thoracic and cervical, above and to the right of the aorta. One familiar with the other relations of the vessels will anticipate the differential distinctions which are subjoined.

INNOMINATE.	ARCH OF THE AORTA.
The presence of a tumor which can generally be felt and seen at the right sterno-clavicular articulation.	The presence of an external tumor exceptional.

The reason for this distinction is found in the greater depth of the aorta, and in the fact that the least resistance to the growth of the aneurismal sac is in the direction of the chest and not in that of the neck.

Pain over the anterior part of the chest, on the right side of the neck, head, and face, and down the arm and chest of the right side.	Pain deeply situated; often between the shoulders or under the sternum, and frequently encircling the upper part of the chest.

The differential peculiarities of the pain above noticed result from the fact that the cervical nerves are more within the reach of pressure from an innominate than from an aortic aneurism, and that many of these nerves supply the superficial portion of the front and side of the chest, of the neck, face, and head, and also the shoulder and inner side of the arm. That the pain should be on the right side, and not on the left, follows from the situation of the innominate artery on the right of the median line. The chest-encircling pain of aortic aneurism is due to the pressure of the tumor upon the superior intercostal nerves.

Pain generally acute and neuralgic, rarely dull, gnawing, and boring in its character.	Pain frequently gnawing and boring.

The significance of these qualities in the pain of the two affections is important. Pain of an intermittent and acute character generally originates from pressure or irritation of contiguous nerves, while the deep, dull, gnawing kind arises from the erosion of bone, and is common in aortic aneurism, in consequence of the relation of the tumor to the spine. It is doubtful if any tumor except an aneurism produces absorption of bone by external contact. M. Cayol† alleges that he has known a cancerous mass to destroy portions of the dorsal vertebræ. Such cases, however, must be extremely rare; and hence the character of the pain would be a valuable sign in determining obscure cases of supposed aortic aneurism.

* Dublin Journal of the Medical Sciences, vol. xiii., February–May, 1852.
† Dictionnaire de Médecine, art. Estomac, p. 365; quoted by Holland.

Venous congestion and œdema common over the right side of the neck and arm.	Venous congestion and œdema more common over the chest.

This follows, inasmuch as the obstruction to the venous current will be greater from a right than from a median tumor, while pressure upon the azygos veins, which are nearest to the aorta, will explain the dilatation of their anterior thoracic branches in aneurism of the arch.

Dyspnœa and cough common, but not usually intense.	Dyspnœa and cough, as the disease advances, often very severe and persistent.

This difference in the respiratory embarrassment is explained by the fact that the trachea, and the recurrent laryngeal of the left side, are peculiarly exposed to pressure from aortic aneurism by the resistance of the sternum to the forward growth of the tumor. The same facts will explain the more common existence of cough in this form of the disease.

Left lateral deflection of the trachea and of the œsophagus.	No lateral deflection.

This displacement follows from the relative position of the two vessels to the trachea and the œsophagus: the innominate aneurism, being on the right side, pushes them to the left, while an aortic growth, being in front, presses them directly backward.

Numbness and loss of power in the right arm.	These symptoms uncommon.

This arises from the brachial plexus of nerves being nearer to the innominate than to the aorta.

Pulsation in the right radial weak.	Pulsation in both radials weak, though weaker on the left than on the right side.

The feebleness of the pulse in the radials may be affirmed of all the vessels of the two sides, the difference on the two sides being due to the greater tendency of the sac in aortic aneurism to extend towards the left.

Stridor occasional.	Stridor common.

This might be anticipated from the pressure-effects of an aortic tumor upon the pneumogastric and its recurrent laryngeal branch.

Murmurs propagated from the sac in the direction of the subclavian and carotid arteries.	When present, confined to the region of the sac, and may be on the left side and downwards.
Double heart-sounds very common.	Double heart-sounds not common.

These aneurisms will naturally occur in the direction of least obstruction to the onward flow of the blood. It is difficult to explain the double sounds so commonly heard in innominate aneurism: some believe that they are formed in the tumor, and others that they are transmitted from the heart.

Prognosis.—Aneurism of this artery never undergoes a spontaneous cure. The disease proves fatal from hemorrhage, exhaustion, or asphyxia.

Treatment.—Two plans are open to the choice of the surgeon,—the medical and the surgical. The former holds out the best prospect for prolonging the life of the patient, and should, in my judgment, be generally adopted.

The medical treatment is that which has been practiced with encouraging success by Mr. J. Tufnell in aneurism of other vessels, and has been described under the head of aneurism of the arch of the aorta. It consists in confining the patient in the recumbent position in bed, regulating the diet, and mitigating pain by anodynes, to which may be added the use of iodide of potash, in fifteen-grain doses, administered three times a day.

In considering the subject from a surgical stand-point, the question will nat-

urally arise, What can be done for the cure of an aneurism of the innominate artery? In consequence of the shortness of the trunk, two operations are at once excluded from the methods of deligation, namely, the Hunterian and the Brasdor. The only ligature possible under the circumstances, therefore, would be one applied to one or both of the branches of the innominate,—that is, to the common carotid or to the subclavian, or simultaneously to both. This form of ligation is often described as that of Wardrop, and, though distal, differs from Brasdor's in this particular, that in the former, when applied to carotid aneurism, the only one possible where the conditions can be realized, no branch is given off between the ligature and the sac. Is it probable, then, that by tying one or both of the branches of the innominate the current in an aneurismal sac of that vessel would be arrested in a manner which would insure the deposit of stratified fibrin or induce a rapid embolic consolidation of the tumor? Theoretically, the ligation of the right primitive carotid would, as some have supposed, by lessening, not entirely arresting, the circulation through the sac, conduce most to the first mode of consolidation, while the second, or embolic occlusion, would be more likely to follow simultaneous ligation of both the subclavian and the carotid artery. Both of these operations have been performed, and the results will appear from the subjoined list of cases collected by Mr. Heath,* with a few additions:

Cases of Distal Ligature for Aneurism at the Root of the Neck.

I. Aneurism of the Innominate treated by Ligature of the Third Part of the Subclavian.

1. Dupuytren. Died on the ninth day.
2. Wardrop, 1827. Died two years afterwards. Wardrop on Aneurism.
3. Broca, 1862. Died six months afterwards.
4. Bryant, August, 1871. Ligation of the third part of the subclavian. Patient alive in 1873. Bryant's Surgery, p. 294.

II. Aneurism of the Innominate treated by Ligature of the First Part of the Axillary.

1. Laugier, 1834. Died one month afterwards. Lancet, 1834, vol. i. p. 889.

III. Aneurism of the Innominate treated by Ligature of the Right Common Carotid.

1. Evans, 1828. Recovered. Wardrop on Aneurism.
2. Mott, 1829. Died seven months afterwards. Mott's Velpeau.
3. Ashton Key, 1830. Died in a few hours. Medical Gazette, vol. vi.; Guthrie on Arteries.
4. Case reported by Neumeister, 1830. Died five days afterwards. Holland, Dublin Quarterly Journal, February, 1852.
5. Morrison, 1832. Died one year and eight months afterwards. American Journal of the Medical Sciences, vol. xix. p. 329.
6. John Scott. Died. Lancet, 1834–35, vol. i. p. 893.
7. Dohlhoff, 1837. Died on the sixth day. Broca on Aneurism, p. 632; Rust. Magazine, 1838, vol. li. p. 529.
8. Fergusson, 1841. Died seven days afterwards. London and Edinburgh Journal, 1841, vol. i. p. 786.
9. Porta, 1842. Died forty hours afterwards. Porta, Alt. patol. delle Art., p. 35.
10. Hutton, 1842. Died sixty-six days afterwards. Dublin Journal, vol. xxv. p. 499.
11. Vilardebo, 1843. Died twenty-one days afterwards. Archives Générales de Médecine, 1847, p. 547.
12. Campbell, 1844. Died on the nineteenth day. London and Edinburgh Journal, 1845.
13. Rompani, 1844. Died on the twenty-first day.
14. Wright, 1855. Died sixty days afterwards. Montreal Medical Chronicle, April, 1856.
15. Ordile, of Naples, 1850. Died. Verbally communicated to Holmes by operator.
16. Lane, 1852. Died in two months.
17. Addinell Hewson, 1867. Died twelve days afterwards. Pennsylvania Hospital Reports, 1868, vol. i.
18. Broadbent, 1860. Died on the hundred-and-fifteenth day.
19. A. Newton. Died on the tenth day.
20. Pirogoff. Recovered from the operation, but not cured.
21. Pirogoff. Died three weeks afterwards.

* Holmes's Surgery, vol. iii. p. 576.

IV. Aneurisms of the Innominate treated by Double Consecutive Distal Ligature.

1. Fearn. Carotid, August 30, 1836; subclavian, third part, August 2, 1838. Died four months after the last operation. Lancet, 1837.

2. Wickham. Carotid, September 25, 1839; subclavian, third part, December 3, 1839. Died. Lancet, 1839; Medico-Chirurgical Transactions, 1840.

3. Malgaigne. Carotid, March, 1845; axillary, first part, October 17, 1845. Died. Bulletin de la Société Anatomique, 1848, vol. xxiii. p. 291.

4. Bickersteth, 1864. May 10, subclavian ligated, third part, seven weeks after the common carotid. Died three months and ten days afterwards.

V. Aneurism, supposed to be of the Innominate, treated by Double Simultaneous Distal Ligature.

1. Rossi, 1843. Carotid and first part of the subclavian. Died. Gazette Médicale, 1844, p. 58; Broca on Aneurism.

2. Cuvellier, 1859. Carotid and third part of the subclavian. Died. This proved afterwards to have been a subclavian aneurism. Demme, Spec. Chir. d. Schusswunden, p. 210.

3. Heath, 1865. Carotid and third part of the subclavian. Survived four years. Lancet, January 5, 1867.

4. Hutchison, of Brooklyn, 1866. Carotid and third part of the subclavian. (Some doubt exists as to the last-named vessel being tied.) Recovered from the operation, but died from suffocation on the forty-first day. British Medical Journal, March 30, 1867.

5. Maunder, 1867. Carotid and third part of the subclavian. Died. Pathological Society's Transactions, xix. 93.

6. Sands, New York, 1868. Carotid and third part of the subclavian. Recovered from the operation, but disease not cured. Died thirteen months afterwards. American Journal of the Medical Sciences, April, 1869, p. 568.

(It must be observed that Heath's, Maunder's, and Sands's cases proved afterwards to have been aneurism of the arch of the aorta.)

7. T. Holmes, September 20, 1871. Died four weeks after the operation.

Examining the different operations in detail, and their terminations, we have the following result. In 5 cases the subclavian alone was tied, and of this number 3 died, and none were cured, though 1 lived two years, due, it is supposed, to a circumstance which would probably rarely occur again, namely, the return of circulation in the right carotid, in which it had been absent before the operation. Of those in which the carotid was tied, 20 in number, 1 case, that of Evans, recovered, 2 recovered from the operation without being cured, and 17 died. Of the fatal cases, 2 lived sixty days, 1 one hundred and fifteen days, and the remaining 14 perished at periods varying from a few hours up to twenty-one days. Of the 4 cases treated by ligature of the carotid and the subclavian, with an interval between the operations, all died, at periods varying from seven weeks to four months. Of the 7 cases in which the simultaneous ligature of the carotid and the subclavian was practiced, 4, namely, those of Cuvellier, Heath, Maunder, and Sands, must be excluded from the list of innominate aneurisms, the first having been afterwards found to be subclavian and the last three aortic. This would leave 3 cases, all of which proved fatal. The period at which death followed the operations was as follows: in one case, on the sixth day; in a second, at an uncertain date; and in the third, in the course of a few weeks. Of the four cases which have been excluded, Maunder's died on the sixth day, Sands's lived thirteen months, Heath's four years, and in Cuvellier's the time of death is not stated.

The causes of death following the various operations were secondary hemorrhage, asphyxia, bronchitis, pneumonia, inflammation and suppuration of the sac, exhaustion, and cerebral affections. The disturbance to the circulation of the brain by the ligature of the great blood-vessels in the neck, and the danger from this source, are very well brought out in the tables of Norris. Out of 117 of such ligations performed for various causes, cerebral symptoms followed in 30 cases, and in 17 of these 30 the patients died.

What, then, is the result, in the aggregate, of all the cases of innominate aneurism for which deligation, single, consecutive, and simultaneous, has been employed? We have recorded 35 cases, with only 1 complete and 1 partial cure, that of Evans and that of Wardrop. In Evans's case inflammation twice attacked the sac before the pulsation ceased, the last time being followed by the discharge of pus. It is, therefore, difficult to determine to which

cause the patient owed his recovery,—the ligature or the inflammation. Mr. Guthrie certainly thought it was the latter. It is highly probable that the ligature was indirectly the cause of the cure, by exciting the inflammatory sequences which occluded the sac, but it is not probable that a surgeon would attempt a similar operation with this object in view. In Wardrop's case the patient lived two years, and, as has been stated, the prolongation of life was referred to a return of pulsation in the carotid, in which vessel it had been absent previous to the operation. Of the 33 fatal cases, one-half, or 17, perished at periods varying from a few hours to sixty-two days; the remaining number lived from two and a half to seven months. In only 5 of the fatal cases can it be said that death was not hastened by the operation, while in the rest it certainly was precipitated by it. In some instances the operation has been defended by the statement that, although not successful, the size and the pulsation in the tumor had been lessened after deligation, and that on post-mortem examination it was found that the deposition of fibrin and the formation of blood-clots had already made a considerable advance towards consolidation. In answer it may be said that the arrest of the blood-current through the innominate sac by the distal ligature of one or both of its great vessels would necessarily be followed by a lessened pulsation, as the blood immediately seeks other channels; while the presence of both fibrinous and blood coagula is constantly witnessed in the sac, in some instances even blocking up the carotid or the subclavian artery, in cases where patients die without any operation. While it is true that the number of cases in which deligation has been practiced for the cure of innominate aneurism is too limited for a safe deduction, it is no less true that, to the extent of those at hand, the practical result is against surgical interference. If cures have not been effected, one thing has been reasonably well determined, namely, that the collateral vessels are able to re-establish the circulation after simultaneous deligation of the subclavian and carotid. In the seven cases in which this practice was adopted there was no failure from incompetency of the thyroid axis and the scapular and internal mammary vessels, by their anastomoses, to supply the blood in sufficient quantity for the demands of the neck, head, and upper extremities.

Reasoning from anatomical premises, the simultaneous deligation of the subclavian and carotid arteries offers the best prospect for success in innominate aneurism, as by this measure the greatest degree of quiet is secured to the contents of the sac, a result which is not attainable by the ligature of either the carotid or the subclavian alone, or of both consecutively, for in the first case a large arterial channel is open for the sweep of the blood-current, and in the second the point which has usually intervened between the two ligations has been sufficient for the enlargement of the collateral vessels to a size the aggregate of which will be equal to that of the trunk they substitute. The subjoined cut (Fig. 398) will serve to show the position of the ligatures employed in aneurisms of the innominate, and also the vessels chiefly concerned in establishing the collateral circulation.

FIG. 398.

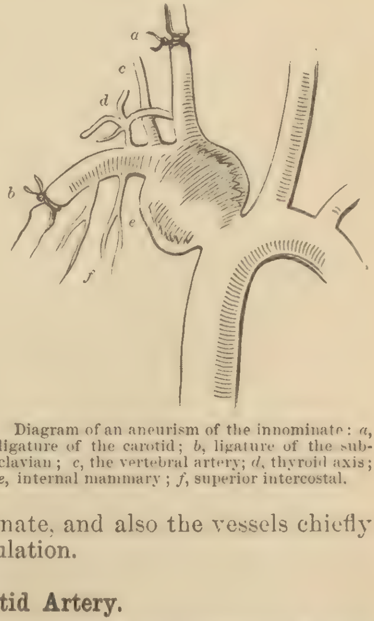


Diagram of an aneurism of the innominate: *a*, ligature of the carotid; *b*, ligature of the subclavian; *c*, the vertebral artery; *d*, thyroid axis; *e*, internal mammary; *f*, superior intercostal.

Aneurism of the Carotid Artery.

Aneurism of the carotid, in consequence of the less liability of this vessel to atheromatous degeneration, is not of very common occurrence. It is

placed, in frequency, between aneurism of the abdominal aorta and that of the subclavian artery. In 551 cases of aneurism tabulated by Mr. Crisp, 25 were of the carotid. In Lisfranc's collection, numbering 179, there are 17 carotid aneurisms. In the manuscript collection of Hunter and Griffiths before mentioned, there are 162 cases of spontaneous aneurism, 20 of which were carotid. As in other aneurisms, the affection is more common in males than in females, though the disparity in sex in this respect between the disease in the carotid and in other vessels is much less marked. Of the 25 cases of the disease in Crisp's collection, 12 were in women; of the 34 cases in the tables of Norris, 7 were females; in the 20 cases (manuscript) referred to above, 4 were women. When the disease is situated at the bifurcation of the vessel, females suffer as frequently as males. Carotid aneurism is not unfrequently met with in young persons. In 16 cases analyzed by Hunter, 1 was under ten years, 1 between twenty and thirty, 8 were between thirty and forty, and 2 between sixty and seventy. The situation of carotid aneurism is generally near the middle of the vessel, sometimes higher up, occasionally at its bifurcation, and rarely near its origin. The right carotid is oftener the seat of the disease than the left.

The growth of aneurisms affecting this vessel is usually slow, and the pressure-effects are less distressing than in cases of the disease involving the other vessels at the root of the neck.

Symptoms.—The disease appears at first as a small, pulsating swelling, round or oval in shape, and soft and compressible under the fingers. When the ear is placed over the tumor, a distinct thrill and *bruit de soufflet* will be heard, sounds which, together with pulsation, are arrested and the size of the tumor diminished by firm pressure on the carotid between the aneurism and the heart. As the disease progresses and the swelling becomes large, the patient begins to suffer from the effects of pressure. The larynx, trachea, and œsophagus are pushed to one side, and the pneumogastric nerve is compressed, giving rise to impaired respiration, difficult deglutition, and frequently to cough. Pains are experienced in the side of the neck, head, and face, from irritation of the branches of the superficial cervical plexus of nerves; not unfrequently an unusual capillary congestion is present, from pressure upon the sympathetic. When the sac attains sufficient size to obstruct the passage of the blood through the internal jugular, or to interfere with the circulation through the internal carotid, a train of threatening cerebral symptoms is introduced, such as defective vision, vertigo, and stupor.

Diagnosis.—There are a number of enlargements which appear in the neck and which are liable to be confounded with carotid aneurism, among which may be mentioned *enlargement of the cervical lymphatic glands*, *abscess*, *tumors*, *varix of the internal jugular*, *cysts*, *enlargement of the thyroid gland*, and *aneurism* of other vessels at the root of the neck. The tables of Norris* on the ligature of the carotid furnish no less than seven errors of diagnosis in thirty-eight operations.

Enlargement of the lymphatic glands.—The relation which these bodies hold to the carotid (being placed along the sheath of the vessel) is such that when they become enlarged it is not always easy to distinguish the swelling which is formed from that of aneurism. Attention, however, to the following points will generally conduct the surgeon to a correct conclusion. Glandular enlargements are rarely accompanied with either bruit or thrill, and the impulse communicated to these bodies from the artery against which they rest is a heaving one, not an expansive one, as in aneurism. The tumor, when glandular, is irregular, the separate glands composing the enlarged group being generally recognizable by the touch; whereas in aneurism the swelling is smooth. Pressure on the carotid affects the size of adenoid growths slightly, if at all, but sensibly diminishes an aneurism. In addition to these characteristic distinctions may be mentioned the fact that glandular enlargements are in a great degree confined to young persons possessing other marks of a

* Norris's Contributions to Practical Surgery, p. 267.

strumous diathesis, and are frequently multiple,—that is, exist in other regions of the neck,—while aneurism appears, as a rule, at a more advanced age, and in all constitutional conditions.

Abscess.—Scarpa relates a case in which an aneurism of the carotid was opened under the impression that it was an abscess; and the case of Liston,* to which allusion has been made, furnishes another instance of the difficulty which may be encountered in determining the true nature of deep cervical swellings. The formation of a deep abscess is almost always preceded by a diffused induration, tender to pressure, with redness, heat, and œdema of the superincumbent parts, the swelling, after a time, beginning to soften from its centre towards its circumference. In contrast with these characters, aneurism is a circumscribed soft swelling, without undue sensibility, redness, or heat, and, except when of considerable magnitude and obstructing the venous circulation, is unattended by œdema. In deep abscess of the cervical region there is pain, stiffness, and a fixed position of the head and neck, without centrifugal expansion, not affected in size by compression of the carotid artery, and generally associated with constitutional disturbance, as rigors, fever, and sweats. Aneurism is at first without pain, stiffness, or helplessness of the neck, has a radiating expansion, is lessened by proximal pressure, and is not necessarily accompanied by constitutional symptoms. Abscess, at first hard, gradually softens into fluctuation; aneurism, at first soft, continues so, or if hard it is from the formation of fibrinous concretions, and becomes so at an advanced stage of the disease. Lastly, if a doubt still remains it can be settled by the use of a fine exploring-needle.

Tumors.—Encephaloid and sarcomatous diseases frequently appear in the neck. These growths are hard, somewhat irregular in outline, immovable, rapid in their progress, and have, as they advance, a lilac discoloration of the skin, without the tenderness which accompanies the redness of abscess, and are without thrill or bruit; none of which characteristics distinguish aneurism.

Adipose tumors are generally quite movable, lobulated, doughy, without pulsation or sounds, and are not affected by arterial pressure. Aneurism is more fixed, possesses a smooth surface, is soft, with pulsation and sounds, both of which are modified or suspended by compression of the vessel with which the tumor is connected on the cardiac side.

Varix of the internal jugular.—The internal jugular, or one of its tributaries, may form a considerable pouch-like dilatation, which might readily be mistaken for aneurism. I once removed such a tumor from a young woman, which was situated below the angle of the jaw. It was pedunculated and growing rapidly. On carefully uncovering the swelling I was able to trace it to its source, viz., one of the large roots of the deep jugular. A ligature was placed around the narrow part of its connection to the vein before its detachment, and the operation was followed by a rapid recovery. Venous dilatations are much softer than aneurisms; they disappear under very gentle compression, and become distended during expiration, as also by pressure on the proximal side from the interruption offered to the flow of venous blood towards the heart, none of which influences affect an aneurismal tumor.

Cysts are not affected by pressure, yield no pulsation or sounds, and by palpation communicate a sense of fluctuation.

Thyroid enlargements.—It is only when one of the lateral lobes of this body is affected either by hypertrophy or by cystic disease that any difficulty can possibly exist in distinguishing the swelling from aneurism. Goitre generally appears at an early age, and in females; aneurism is most common in more mature life, and is usually in males. In goitre the swelling obeys the movements of the trachea, rising and sinking in the act of deglutition, and can generally be drawn over towards the median line sufficiently far to show its independence of the carotid artery. In aneurism the tumor is not affected by swallowing, and cannot be disengaged from the vessel with which it is

* Cooper's Surgical Dictionary, vol. i. p. 210.

connected. Goitre is usually slower in its growth than aneurism. The pressure-effects of bronchocele are much less serious than those of aneurism. The difficulty of diagnosis is somewhat increased in those cases of thyroid enlargement in which, in consequence of the great dilatation of the blood-vessels of the gland, there are added to hypertrophy two other elements,—pulsation and bruit. A tumor of this kind, receiving its blood-supply from the carotid, will, like aneurism, be diminished in size and will have its sounds suspended by proximal compression. There are, however, certain noticeable distinctions between the two diseases which will serve to conduct the practitioner to a proper judgment. In the thyroid swelling the tumor continues to follow the movements of the trachea, and the enlargement is rarely confined to one lobe, but extends to the median line of the neck and across to the opposite side, affecting both the isthmus and the opposite lobe of the gland. This cannot be said of aneurism. Another very important distinction between the two diseases is the following, viz., that while pressure on the affected carotid will completely arrest pulsation and thrill in aneurism, it does so only partially in the thyroid body. To suspend all movement and sound in the latter it is necessary that the circulation be stopped through both carotids, inasmuch as the thyroid tumor receives its blood from both of these vessels.

Brachio-cephalic and aortic aneurisms.—A carotid aneurism may extend so low down in the neck, or an aortic, innominate, or subclavian aneurism may extend so far up into the same region, that no amount of skill will be sufficient to distinguish the latter from the former. Mr. Cockle* relates four or five cases of supposed aneurism of the carotid and of the innominate in which ligation was performed, which, on post-mortem examination, proved to be aneurism of the arch of the aorta. The surgeon must be guided by such information as can be gained from a searching inquiry into the early history of the case, discovering, if possible, the exact locality of the swelling, whether commencing below and extending up, as would be the course of an innominate or a carotid aneurism, or beginning above and growing downward, as would be probable in a carotid tumor. Lateral deflection of the trachea and the œsophagus, should it exist, would exclude aneurism of the arch of the aorta.

Termination.—Carotid aneurism, when allowed to advance without interference, usually runs its course in from twelve to eighteen months, the patient dying from the effects of pressure, from gangrene of the sac, or from ulceration and hemorrhage, the blood often being poured into the trachea or bronchia, or into the chest. In some instances embolism of the cerebral blood-vessels has carried off the patient.

Treatment.—Three methods are employed for the treatment of carotid aneurism, namely, *rest*, *compression*, and *ligation*.

Rest.—This plan has been described in connection with aneurism of other arteries, and does not differ in detail from that enforced for similar disease of the aorta. It should always be first adopted, as in the event of failure the prospect of success by other methods will be materially enhanced.

Digital compression.—When the aneurism is situated sufficiently high to admit of the fingers being placed between the tumor and the origin of the carotid, there will be a strong probability of effecting a cure. M. Rouge, of Lausanne,† succeeded in consolidating an aneurism of the carotid by digital compression in seventeen days, the pressure being maintained on an average about seven hours each day. More recently five other cases successfully treated by this plan have been recorded: one by Mr. Sheppard, of Worcester Hospital,‡ one by Dr. J. G. Kerr, of Canton, China,§ one by Mr. Holmes,|| one by Mr. Gay, and one by Sir R. Dagin, mentioned by Crisp.¶ The

* Lancet, 1869, vol. i. p. 489.

† Boston Medical and Surgical Journal, vol. iv., N. S., p. 179; quoted from British Medical Journal.

‡ Medical Times and Gazette, 1863, vol. ii. p. 643.

§ American Journal of the Medical Sciences, vol. liii., April, 1867.

|| Lancet, June 21, 1873, p. 868.

¶ Lancet, 1872, vol. i. p. 470.

pressure must be made by relays of assistants, and should be applied at the root of the neck, under the anterior edge of the sterno-cleido-mastoid muscle, with sufficient force to thrust the vessel back against the transverse process of the seventh cervical vertebra. To render the pressure most effective, the head should be flexed, in order to relax the sterno-mastoid muscle and thus allow the finger or the thumb to sink easily down upon the artery. The internal jugular at this position in the neck is sufficiently distant from the carotid to be out of reach of the pressure. The plan pursued by M. Rouge is well worthy of imitation. The artery was grasped between the thumb and three fingers, the former being placed along the front, and the latter along the posterior, edge of the sterno-cleido-mastoid. In this way the vessel was subjected to bilateral pressure, by which any inconvenience resulting from irritation of the pneumogastric or sympathetic nerves was avoided. Should the patient experience much pain during the treatment, the compression may be rendered endurable by the hypodermic use of morphia. When neither proximal pressure nor ligation is possible, digital compression might be advantageously made on the distal side of the swelling.

Ligature.—Deligation may be performed both on the proximal and on the distal side of the tumor.

Proximal ligature.—This is the preferable mode of tying the vessel, and should always be practiced when the aneurism occupies the middle or the upper part of the artery, admitting of deligation between the innominate and the tumor, or, when on the left side, between the disease and the arch of the aorta, in the cervical portion of the carotid.

Distal ligature.—When, in consequence of the bulk or the position of the aneurism, it is impossible to ligate on the cardiac side, the operation of Brasdor may be done. Should the case be one for surgical treatment, the common carotid may be tied above the sac, or, if the latter be too near the division of the vessel, simultaneous deligation of the external and internal carotids may be performed. The ligature of the innominate holds out no encouragement whatever, and may be justly excluded from consideration. Should the disease be of so aggravated a nature as to preclude any operative procedure, there is still left one hope, though a forlorn one, viz., the plan of Valsalva. There is recorded at least one cure of a carotid aneurism by this method;* and what has occurred once may occur again.

Results of ligation.—Of 25 cases of carotid aneurism recorded by Mr. Crisp,† 21 were treated by ligature. Of these operations 10 were successful, and 11 proved fatal. In 5 of the patients the ligation was done on the distal side, of which number 3 recovered, and the lives of the remaining 2 are represented to have been prolonged. The causes of death in the fatal cases were, in 5 hemorrhage, in 2 inflammation of the sac and artery, in 1 spasm of the glottis, and in 3 doubtful. Dr. Norris‡ has tabulated 38 cases, with 16 deaths and 22 recoveries. The collection of Hunter and Griffiths§ contains 24 cases, with 11 deaths and 13 recoveries. The statistics of Dr. Pilz,‖ of Breslau, comprise 87 cases of ligature for carotid aneurism, 31 of which number died. Thus we have an aggregate of 170 deligations for this disease, with 69 deaths, or 40.6 per cent. The distal ligature of the carotid for aneurism has been applied eight times, as follows:

1. In 1826, by Wardrop. Patient recovered.
2. In 1826, by Wardrop. Patient not improved.
3. In 1827, by Lambert. Patient died from a hemorrhage, which came from the vessel above the ligature, though the aneurism was cured, being filled with fibrin and blood-clots.
4. In 1827, by Bush. Patient recovered.
5. In 1829, by Montgomery. Patient died.

* Boston Medical and Surgical Journal, 1829, vol. ii. p. 339.
† Crisp on Aneurism, p. 218.
‡ Contributions to Practical Surgery, p. 263.
§ Manuscript collection.
‖ Langenbeck's Archives, 1868, vol. ix.

6. In 1840, by Colson. Patient recovered.
7. In 1840, by Demme. Patient died.
8. In 1852, by Lane. Patient died.

Of the above 8 cases 3 recovered and 5 died. This is a heavy mortality; but no authoritative conclusion can be drawn from data so limited, and, in view of the hopeless future which is before a patient so situated, I should consider myself amply vindicated from the charge of rashness if I performed distal deligation on the strength of such precedents.

The period at which the ligature separates varies in different cases. In those collected by Norris, 21 in number, the thread came away in 13 before the twentieth day, in 7 between the twentieth and the thirtieth day, and in 1 on the thirty-third day. In Dr. Hunter's collection of 16 deligations for carotid aneurism, the time at which the ligature became detached was ascertained in 10 instances, as follows: 3 between the tenth and the fifteenth day; 2 between the fifteenth and the twentieth day; 4 between the twentieth and the thirtieth day; and 1 between the thirtieth and the fortieth day.

The chief cause of death, after ligation, is hemorrhage, either from suppuration of the sac or from the artery after separation of the ligature. In one instance noticed by Norris the bleeding did not occur until seventy days after the operation. Death may also follow from cerebral disturbance, and from bronchitis, or from an insidious inflammation of the lung. The connection between this last-named sequel and carotid ligature is very imperfectly understood. Mr. Erichsen is disposed to attribute the pulmonary disease to "derangement in the functions of the brain and medulla oblongata," produced by a disturbed intracranial circulation, and disposing, secondarily, through these centres to a condition of pulmonary congestion favorable to the development of pneumonia. I believe that had a careful examination been instituted in cases fatal from this cause, it would have been found that the pneumogastric nerve had sustained some damage during the operation. I have known death from inflammation of the lungs to occur twice from this cause. Death from bronchitis is a very common result after cut-throat wounds, and I have reason to believe it arises from damage sustained by the superior laryngeal branch of the pneumogastric nerve, causing congestion and inflammation of the laryngeal mucous membrane, which is propagated by tissue-continuity to the respiratory passages below. To the nerve-injury also may be attributed the spasmodic cough which occasionally follows the ligature of the carotid.

Cerebral or pulmonary disorders should be treated as are similar affections arising from other causes, namely, by local or general bleeding, counter-irritation, cathartics, and a regulated diet.

Aneurism of the External Carotid.

Aneurism of the external carotid, except from traumatic causes, is exceedingly rare, so much so that many surgical authors make no allusion whatever to the subject. Dr. S. W. Gross has reported the case of a negro woman in whom, six months after she had been wounded in the neck with a pistol, a pulsating tumor appeared below the angle of the jaw, which increased in size until it measured eight inches in one direction and five inches in the other.

Treatment.—In the event of an aneurism of the external carotid, digital compression should be first tested, and, that failing, deligation of the common carotid should be performed. In Dr. Gross's case, to which allusion has been made, this course was adopted, with the effect of making a perfect cure, the tumor having entirely disappeared in the course of a twelvemonth.

Aneurism of the Branches of the External Carotid.

The temporal, facial, posterior occipital, and the branches of the internal maxillary have all been the subjects of aneurismal enlargement, and, as in dilatation of the parent trunk, the disease has followed some kind of injury.

In 1870 a male patient, forty years of age, presented himself at my office with a spontaneous aneurism of the occipital. The tumor was the size of a hickory-nut, and projected between the trapezius and complexus muscles. As the disease had existed for over a year, and appeared to be stationary, it was allowed to remain without interference. I have also seen one example of an aneurism of the middle meningeal artery in a dissecting-room subject. The tumor had made for itself a considerable concavity by the absorption of that portion of the parietal bone against which it lay, and, judging from the extremely thin layer of the external table remaining, would certainly, had the patient survived, have appeared in a short time on the external surface of the skull. Such an event has occurred, and the unfortunate patient lost his life through the surgeon's laying open the swelling with a bistoury under the impression that he had to deal with an ordinary abscess. Professor Gross saw a case of aneurism on the anterior branch of the temporal artery, which had been induced by an injury sustained by the vessel in cupping.

Treatment.—If the vessel is accessible to the touch, an effort should be made to secure consolidation in the contents of the sac by digital compression. In the event of this failing, the artery and the sac should be exposed by turning aside, by a careful dissection, the superincumbent tissues, and the vessel ligated above and below the tumor, with the animal thread; after which the reflected flaps are to be restored to their original position, and maintained in place by the interrupted suture or by adhesive strips. The sac should not be opened.

Aneurism of the Internal Carotid.

The internal carotid may be the subject of aneurism in its *cervical*, *petrous*, and *intracranial* portions. Aneurism of the intracranial portion may be further divided into aneurism of the *trunk* and of its *branches*.

When the cervical portion of the vessel becomes the seat of aneurism, the case assumes the deepest interest, from the obscurity which environs the swelling. The deep situation of the artery, covered as it is externally by the stylo-hyoid, stylo-pharyngeus, and stylo-glossus muscles, and by dense aponeurotic structures which extend down to the styloid process, prevents any very marked prominence of such a tumor on the surface of the neck, and, as the artery is separated from the pharynx only by the mucous membrane and the constrictor muscle, its extension inward becomes an anatomical necessity. Indeed, in this peculiarity lies the chief difference between aneurism of the internal carotid and aneurism situated at the division of the common trunk. Such a pharyngeal protrusion might be mistaken for an enlarged suppurating tonsil, and be punctured with a bistoury; though the symptoms of pulsation, which can be both felt and seen in aneurism, would render an error of this kind as inexcusable as it would be disastrous.

Aneurism of the petrous and intracranial portions will be considered in a subsequent section.

Treatment.—Digital compression of the common carotid merits a trial before a more radical measure is decided upon, and should this not succeed, the only course will be the ligature of the primitive carotid, an operation which has, so far as I can determine, been done but once,—by Mr. Syme,—and then with a fatal result.

Aneurism of the Subclavian Artery.

The subclavian artery is the subject of aneurism almost as frequently as the carotid. In the tables of Mr. Crisp it occurred twenty-three times in 295 cases. It is most common in men. In the late Mr. Poland's collection of subclavian aneurisms,* numbering 120, there are 100 males and 11 females; in 9 cases the sex was not ascertained. In 85 the disease was on the right

* Guy's Hospital Reports, 1870.

side, and in 28 on the left; 72 were idiopathic, and 13 traumatic. In 57 cases collected by Dr. Norris, 50 were males and 7 females. As far as could be ascertained, 31 were on the right side and 23 on the left. The greater tendency in the right vessel to become diseased is perhaps due to the muscular and vascular strain to which the right arm, from its general use, is subjected. The largest number of cases occur between the fortieth and fiftieth years of life. The disease is rarely, if ever, seen under thirty. In a few instances both arteries have been simultaneously affected. Although every part of the vessel may be the seat of the disease, yet the third part of the subclavian, that portion which lies external to the scaleni muscles, suffers most. When the left subclavian is the seat of an aneurism, it is always in its cervical portion. Of 25 cases of subclavian and subclavio-axillary aneurisms reported by Koch,* 17 were spontaneous, 4 were caused by sprains and contusions, and 4 by fracture.

Symptoms.—The subclavian artery, being deeply placed and sheltered by the clavicle, may be considerably dilated before the disease is discovered. Usually, however, the tumor will be recognized as a small ovoid swelling, its long diameter lying parallel with the course of the clavicle. When the shoulder is drawn downward the swelling will become noticeable. When the fingers are placed in contact with the tumor, that peculiar, expansile, life-like pulsation which belongs to aneurismal disease will be felt; and if the ear be placed over the subclavian region there will be heard the characteristic bruit and thrill. As the tumor increases it tends to extend upward and outward, never inward, and occupies the posterior inferior cervical triangle. The resistance which the sac encounters between the clavicle and the first rib prevents the aneurism from enlarging in the direction of the chest, except in rare cases. In one instance I knew the tumor to develop downward; the first two ribs became absorbed, and the sac entered the chest and contracted adhesions to the lung, into which it finally opened, destroying the patient by hemorrhage. As the disease progresses and fills up the subclavian space, severe pressure-effects are experienced. These are such as result from encroachment on the contiguous nerves and veins. As the artery is crossed by the phrenic nerve, there may be irregular muscular action of the diaphragm; and if the brachial plexus is pressed upon, loss of power will follow, and a sense of numbness will be experienced in the arm and hand, often attended with œdema from the obstruction offered by the tumor to the free passage of the blood through the subclavian vein. The internal jugular also may experience pressure from the growth of the sac, which will account for the dilated condition of the external and anterior jugulars, as well as of their branches, frequently witnessed in the advanced stage of subclavian aneurism. Should the sac become greatly misshapen, or be occupied by coagula of blood or of fibrin to any great extent, the channel through the aneurism may be so changed that the strength of the arterial pulse will be diminished both at the wrist and in the carotid.

Diagnosis.—Although the surgeon is generally able to recognize the true nature and position of this disease, in some instances the diagnosis is one of great difficulty. A number of times the subclavian artery has been ligated under the supposition that an aneurism existed, when really no such affection was present; and in some cases the aneurism has been supposed to be subclavian, when it was afterwards proved to be carotid, innominate, or aortic. Tumors, enlarged glands, and exostoses springing from an adjacent rib are all liable to be confounded with the aneurism under consideration. When the examination is made early in the history of the case, subclavian aneurism will be found to be situated more externally, towards the outer edge of the clavicular portion of the sterno-cleido-mastoid muscle, and higher in the neck, than a similar tumor of the innominate or of the arch of the aorta. The thrill in the first will generally be propagated in the direction of the arm, while in aneurism of the

* Langenbeck's Archives, vol. x.

last two vessels the sounds are either median or in the course of the carotid. Long before an aneurism of the arch of the aorta, or of the innominate, could reach the normal position of the subclavian artery, the characteristic pressure-effects, so unlike those which arise from enlargement of the last-named vessel, would be present to a distressing degree. Aneurism of the subclavian artery does not usually attain anything approaching in size that of aneurism of the vessels with which we are contrasting the disease. Between glandular tumors and subclavian aneurism there are two notable distinctions. In the first the swelling is hard and irregular, and the disease is generally met with in young persons; in aneurism the enlargement is regular, soft, or at least not indurated, and the disease is seldom seen at an earlier period than the thirtieth year. Glandular enlargements are as common on one side of the neck as on the other; subclavian aneurism is most frequently seen on the right side. In other tumors, such as cysts, adipose growths, and malignant disease, the active expansive or centrifugal pulsation, and the distinct thrill, which belong to aneurism, will be absent. Besides, excluding malignant disease, the pressure-effects of other tumors are comparatively unimportant. In abscess there is a previous history of local tenderness, swelling, induration, and central softening, symptoms which do not belong to the early history of aneurism.

The prognosis in subclavian aneurism is very unfavorable. The sac may open internally, causing a diffused extravasation of blood through the neck, or it may burst into the cavity of the chest, or into the lungs, or into some other portion of the air-passages, and destroy the patient. Sometimes the sac opens externally, from ulceration or from gangrene, and proves fatal by hemorrhage. In a few instances the disease undergoes a spontaneous cure. This result followed in 4 out of 22 cases of the disease reported by the late Mr. Poland.*

Treatment.—The means employed for the treatment of subclavian aneurism are the following:

1. *The expectant and the medical.*—This plan has not been tested on as large a scale as it merits. Among the cases tabulated by Mr. Poland, to which reference has been made, 35 were managed by this mode of treatment; 11 recovered, 23 died, and 1 was relieved. Such a result is sufficiently encouraging to entitle to favorable consideration the treatment by rest and diet and the other details of Mr. Tufnell's method, to which should be added the administration of the tincture of veratrum viride and the iodide of potash.

2. *Compression.*—In consequence of the anatomical relations of the artery it is necessary that the pressure, in most cases, should be made directly upon the sac. Three cases treated in this manner—two by Warren, of Boston, and one by Carner—proved successful. The pressure was made in the first two instances by a weight. To execute this method properly, a piece of rubber or felt should be first moulded to the surface of the tumor, and its concavity partially filled with a compress of soft lint. After applying the cup over the aneurism, it can be bound on as firmly as may be necessary by the spica bandage of the shoulder. When the aneurism occupies the first portion of the vessel, distal compression of the artery can be made against the first rib, as it passes from the neck into the axilla. In a case in which it was tried at the Philadelphia Hospital, no benefit was realized. A conical graduated compress, and the fingers of assistants, constitute the best means of applying such pressure. If the aneurism is small, and confined to the third part of the artery, digital pressure might be practiced over the tracheal third. Mr. Poland succeeded in effecting a cure of one case in this way.

3. *Ligature.*—The ligature has been applied both on the cardiac and on the distal side of the disease. There are two operations which have been practiced on the cardiac side, namely, ligature of the innominate and ligature of the first part of the subclavian, or that portion on the tracheal side of the scaleni muscles.

* Guy's Hospital Reports, 1870.

Ligature of the innominate has been performed twelve times for subclavian and subclavio-carotid aneurism, and in every case but one, that of Smyth of New Orleans, with a fatal result. When it is considered that death has, with this one exceptional case, been greatly hastened by the operation, it may be regarded, when practiced for aneurism, as an unjustifiable procedure.

Ligature of the subclavian within the scaleni muscles.—This operation is feasible on the right side, when the dilatation affects the second and third portions of the artery; but its results have been as unsatisfactory as those of deligation of the innominate. In 1846 this operation was done on the left side by Dr. J. Kearney Rodgers, of New York.* An interesting case of subclavian aneurism has been reported by Dr. Willard Parker,† in which that surgeon tied the carotid half an inch above its origin, the subclavian near to the innominate, and the vertebral one-quarter of an inch above its root. On the twelfth day the ligature came away from the vertebral; on the fifteenth, from the carotid; and on the twenty-fourth day, from the subclavian. The patient died on the forty-second day, from secondary hemorrhage. Of 13 cases in which this vessel has been tied, all terminated fatally, three-fourths of the patients dying from hemorrhage. When we consider the position in which a ligature on this part of the vessel must be applied, such a result is not surprising. Close on the inner side are the innominate and the carotid, and on the outer side the vertebral, internal mammary, and superior intercostal arteries, and the thyroid axis, a proximity of blood-vessels which must render the formation of a permanent clot extremely improbable. Should such an operation ever be contemplated, the probability of success would be slightly enhanced by tying at the same time the thyroid axis and the carotid artery. Under no circumstance is the operation worthy of repetition.

Ligature external to the scalenus anticus.—When the aneurism is situated near the termination of the subclavian artery, or at the outer portion of its third part, in which case the axillary vessel is usually implicated, a ligature can be applied to the artery at the external border of the scalenus anticus muscle, or even under the latter by dividing some of its fibres. Poland records‡ 21 instances of this operation, 9 of which recovered and 12 died; 3 of the 9 recoveries were in cases of subclavian aneurism proper. In the remaining cases the axillary and subclavian had both been involved. Koch § reports 65 cases, with 36 recoveries. In most instances the deaths were caused by hemorrhage.

Distal ligature.—Theoretically, it would be supposed that distal ligature, in cases where the aneurismal tumor occupies the inner and middle portions of the vessels, rendering it impossible to place a ligature on its cardiac side, would promise a reasonable hope of success by lessening the rapidity of the flow of blood through the sac to the upper extremity, and thus favoring its coagulation within the aneurism. Experience, however, has not confirmed such a hope. The operation has been done by Dupuytren, Schuh, Canton, and Pétrequin. The ligature was applied by these surgeons to the first part of the axillary, and in all cases with a fatal result. On the same principle Butcher tied the carotid in one case, which ended fatally a few days after the operation.

4. *Galvano-puncture.*—In one case, that of Abeille, the patient was cured by this agent; but the danger attending this method does not commend it to professional confidence.

5. *Manipulation*, recommended by Sir William Fergusson, has been employed 6 times, with 3 recoveries, 2 deaths, and 1 unsuccessful case, by Liddell. The objections to this method of treating aneurism have been already stated; and as the tables of Poland and Koch contain in some instances the same cases, I have taken the collection of the latter, as giving the largest number. They are just as forcible when the plan is applied

* New York Journal of Medicine, 1846.

† New York Medical Record for 1867, vol. ii. p. 97; American Journal of the Medical Sciences, 1864, p. 562.

‡ Guy's Hospital Reports, 1870.

§ Archives Générales de Médecine, Août, 1869; also Langenbeck's Archives, vol. x.

to subclavian aneurism as when it is applied to the disease located elsewhere.

6. *Amputation.*—Sir William Fergusson proposed amputation at the shoulder-joint, and the suggestion was successfully carried into effect by Mr. Spence, of Edinburgh. Except in the solicitation of the blood by the presence of the upper extremity, I cannot see wherein consists the difference between this plan and that of tying the axillary immediately below the clavicle.

7. *Acupressure.*—In a case of subclavian aneurism, Mr. Porter, of Dublin, tried the effect of acupressure applied to the axillary artery. The patient died from hemorrhage six weeks after the operation.

8. *Injections.*—These are used in two ways,—by being thrown into the sac, and into the cellular tissue exterior to the latter. Pétrequin, after failing by the ligature to cure a case of subclavian aneurism, injected into the sac a solution of perchloride of iron. The fluid secured the coagulation of the contents of the aneurism and arrested all pulsation in the tumor, but the patient perished subsequently by hemorrhage from the place where the artery had been ligated. In two other cases the remedy was followed by a fatal result. Langenbeck has employed successfully in one case hypodermic injections of a solution of ergotin.

In order that some safe conclusion may be reached in regard to the treatment of subclavian aneurism, I compare first the different modes of ligation. They are as follows:

1. Ligature of the innominate, 13 times, with 1 recovery.
2. Ligature within the scaleni muscles, 13 times; all fatal.
3. Ligature of the second and third parts of the subclavian, 65 times, with 36 recoveries.
4. Distal ligature, 5 cases; all fatal.

The subject of ligation for subclavian aneurism is, therefore, narrowed down in proper cases to the operation on the third part of the artery.

If now we review the remaining methods, it will be seen that by expectant and medical measures there were treated 35 cases, with 11 recoveries, 23 deaths, and 1 much relieved; by compression, 4 cases, with 4 cures; by galvano-puncture, 1 case, with 1 cure; by manipulation, 6 cases, with 3 recoveries, 2 deaths, and 1 unsuccessful; by amputation, 1 case, with 1 recovery; by acupressure, 1 case, with 1 death; by injection into the sac, 3 cases, with 2 deaths and 1 failure; by injections around the sac, 1 case, with 1 cure.

Contrasting the various plans at our command for the treatment of subclavian aneurism, it will, I think, be conceded that the expectant and medical treatment should be first tried, with or without compression, according to the position of the tumor. These failing, possibly next in order would come manipulation; and in the event of this proving useless, then the ligature of the subclavian artery external to the anterior scalenus muscle, when the situation of the aneurism will permit.

Aneurism of the Vertebral Artery.

Aneurism of the cervical portion of the vertebral artery has been noticed by three or four writers. The disease, however, is exceedingly rare. The diagnosis of such an aneurism would be a matter of great difficulty, in consequence of the deep situation of the artery, and hence we find that the common carotid was tied in two instances under the impression that the tumor was connected with this vessel or with one of its branches; both cases proved fatal. The existence of a firm pulsating tumor on the side of the neck or below the mastoid portion of the temporal bone, having an aneurismal thrill, its pulsation and sound not affected by compression of the primitive carotid, but diminished by strong pressure made directly backwards behind the sternal extremity of the clavicle when the head is flexed, would furnish strong evidence of the disease being connected with the vertebral artery. In a spontaneous aneurism of this vessel digital compression could be of no value, as the great

depth of the artery places it beyond the exercise of any effective force of this kind. Should the tumor be sufficiently high in the neck, the deligation of the vertebral artery would be indicated.

Intracranial Aneurism of the Carotid, the Vertebral, and their Branches.—The internal carotid may become aneurismal at any point in its course from the cerebral extremity of the carotid canal in the petrous portion of the temporal bone, to the optic foramen. That part which lies in the sella Turcica of the sphenoid bone, and where it gives off the anterior cerebral, is most frequently affected, and may give rise to intraorbital disease. As compared with other intracranial aneurisms, those of this portion of the vessel occur about once in every eight cases. In the collection of Sir William Gull,* embracing 62 cases, the carotid on the side of the cavernous sinus was affected eight times; and in an interesting paper on the subject of intracranial aneurism, by Dr. James H. Hutchinson,† of Philadelphia, the same portion of the artery was found to be involved ten times in 85 cases. Aneurism within the skull, whether affecting the carotid or its branches, like the disease elsewhere, is more common in males than in females, and increases in frequency up to the sixtieth year of life. In the analysis of Dr. Hutchinson, to which reference has just been made, 48 of the patients were males and 32 females, and in 5 the sex is not given; 9 were under twenty years of age, 12 between twenty and thirty, 13 between thirty and forty, 14 between forty and fifty, 19 between fifty and sixty, 8 between sixty and seventy, 9 between seventy and eighty, and 1 between eighty and ninety.

The intracranial vessels most commonly affected are the internal carotid, the middle and anterior cerebrals, and the vertebral. Of 27 cases of intracranial aneurism, 10 were found connected with the basilar and 5 with the carotid artery.‡

The relative frequency with which the different arteries of the brain are the subjects of aneurism will appear from the subjoined tables of Sir William Gull and Dr. Hutchinson:

SIR WILLIAM GULL.
62 Cases of Intracranial Aneurism.

Vertebral artery and its branches.	Vertebral,	4 times.
	Basilar,	20 "
	Posterior cerebral,	3 "
	Capillary vessel,	1 "
Carotid artery and its branches.	Internal carotid, at the sella Turcica,	8 "
	Middle cerebral,	15 "
	Anterior cerebral,	6 "
	Anterior communicating,	1 "
	Posterior communicating,	4 "

DR. JAMES H. HUTCHINSON.
85 Cases of Intracranial Aneurism.

Vertebral artery and its branches.	Vertebral,	4 times.
	Basilar,	25 "
	Posterior cerebral,	2 "
Internal carotid and its branches.	Internal carotid,	10 "
	Middle cerebral,	26 "
	Anterior cerebral,	9 "
	Anterior communicating,	5 "
	Posterior communicating,	2 "
	Middle meningeal,	1 "
	Superior cerebral,	1 "

The sacs of these tumors are generally cylindrical, and consist of all the coats of the vessel. These dilatations vary greatly in size, ranging from the dimensions of a grain of shot to those of a walnut. Bouchard and Charcot have drawn attention to what are termed miliary aneurisms, most common in advanced life, and which consist of minute saccular dilatations of the small cerebral vessels, the result, as these writers believe, of periarteritis. When I consider the thinness of the walls of the intracranial arteries, vessels so much under the influence of the heart's action and receiving so little support from the substance of the brain, it is to me a matter of surprise that aneurismal dilatation of the arteries within the cranium is not more common than observation would seem to indicate. As compared in frequency with other aneurisms, Mr. Crisp found, in 551 cases of the disease, that 7 were intracranial.

* Guy's Hospital Reports, vol. i., 1859. † Pennsylvania Hospital Reports, vol. ii., 1869.
‡ Cooper's Surgical Dictionary, vol. i. p. 226.

Effects.—The presence of an aneurismal tumor within the cranium may induce inflammatory softening of the brain-substance, with all its attendant phenomena, or the tumor may burst and form an extravasation or clot, which will occasion paralysis or complete apoplexy. When the tumor lies near one of the bones of the cranium, the latter may become absorbed to a considerable extent.

Symptoms.—There are no signs indicative of intracranial aneurism which are not common to other and diverse diseases of the brain. There may be pain, hemiplegia, more or less complete loss of articulation, difficult deglutition, defects of vision, facial paralysis, obtuseness of hearing, and mental imbecility. Considering the subject from a physiological point of view, and bearing in mind the fact that most of the cases of intracranial aneurism are found in those vessels which are situated on the pons Varolii, the presence of difficulty in deglutition, in hearing, and in articulation, together with defects in the motor-sensory apparatus, though not decisive of intracranial aneurism, furnishes a sort of presumptive evidence of the existence of such a disease, especially if, associated with these symptoms, a thrill is detectable through the walls of the cranium by stethoscopic examination.

Treatment.—It would be proper to contemplate surgical interference only in a case of suspected intracranial aneurism. When the peculiar whirr belonging to this character of disease is distinctly marked, and when the cephalic symptoms are steadily progressing, the ligation of the common carotid on the affected side would be entirely proper. This was done in one case with entire success by Mr. Coe, of Bristol.

Intraorbital Aneurism.

The subject of intraorbital aneurism is one which has caused no small amount of discussion. The disease is not a common one, and its true nature may be said to be still enveloped in much obscurity. The attention of the profession was first drawn to the subject by Travers, and for some time these pulsating tumors within the orbit were regarded as aneurisms by anastomosis, or, as they are at present more properly termed, angeiomatous growths. The investigations of Busk* and of Nunneley, however, would seem to render it probable that in most of the cases which have been observed the disease was truly aneurismal, either spontaneous or traumatic, and that the vessel involved was in some instances the ophthalmic, and in others the cavernous portion of the intracranial carotid. It is further believed that in all cases of a nævoid or angeiomatous character the disease appears before or shortly after birth, and is frequently associated with a similar condition of some portion of the tutamina oculi; indeed, that it involves all the arteries and veins in and around the orbital region. One of the strongest arguments against the nævoid character of the tumor, as it generally appears, is that used by Nunneley, which the experience of those who have had opportunities of treating the disease will corroborate,—namely, that intraorbital aneurism is usually curable by the ligation of the common carotid, whereas in ordinary erectile growths ligation of the chief vessel leading to such tumors is often unsuccessful. The tables of Norris contain 42 ligations of the carotid done for erectile growths about the face and head: of this number, 20 were cured, 13 died, and 9 recovered from the operation, though not cured. Among these 42 cases, 11 were operations for what is termed erectile tumors within the orbit,—doubtless intraorbital aneurism,—10 of which were cured and 1 died. This result is strikingly confirmatory of the statement made by Nunneley. A few opportunities have been offered for the examination of this form of intraorbital disease by dissection. In those in which such examinations have been made, the morbid conditions have not always been uniform. In Nunneley's case the autopsy was made four years after the carotid had been tied, and established the

* Medico-Chirurgical Transactions, vol. xxii. p. 133.

aneurismal nature of the tumor, as an obliterated sac of the ophthalmic artery was found at the sella Turcica: the vessel also contained patches of atheroma. In Delen's cases* the disease seems to have been either arterio-venous, a communication having existed between the internal carotid and the cavernous sinus, or to have been caused by a coagulum in the last-named venous canal. This was very much the condition in a case of Bowman's, in which the carotid was tied for what was believed to be an intraorbital aneurism. The patient died, and on an examination of the parts a coagulum was found blocking up the ophthalmic vein at the point where it enters the cavernous sinus. No disease whatever existed in the arteries, either in or posterior to the orbit. In a fatal case of large pulsating tumor of the orbit, in which the carotid was ligated by Dr. Thomas G. Morton, a net-work of anastomosing vessels was found at the autopsy occupying the inner and front portion of the orbit. No other evidence of arterial or venous disease existed. In a second case operated on by the same surgeon, which proved fatal twenty-four hours after the carotid was tied, all the nerves and blood-vessels which entered the sphenoidal fissure were matted together by inflammatory lymph, and the ophthalmic vein and the cavernous and circular sinuses were found filled with coagulated blood. The carotid artery was sound. Taking the cases of pulsating intraorbital tumors of Nunneley,† Morton,‡ and Rivington,§ in which the pathological conditions have been verified by post-mortem examination, making in all fourteen, eight of the number were found to have been produced by varicose enlargement of the ophthalmic vein, from causes which were post-orbital and chiefly in the cavernous sinus.

FIG. 399.

Intraorbital aneurism,—the prominence of the eyeball quite marked.—Morton.

The presumption, therefore, is that there are four forms of pulsating intraorbital tumors: 1, aneurism, spontaneous and traumatic, of the ophthalmic and of the carotid, beginning either in the orbit or in the sella Turcica; 2, arterio-venous aneurism, in which an opening exists between the internal carotid and the cavernous sinus; 3, angeiomatous or erectile formations, in which all the arteries and veins within the orbit, and occasionally in the soft parts about the orbit, participate; and, 4, obstructive tumors, which are produced by embolism or by pressure at the cavernous sinus arresting the flow of blood through the intraorbital veins. Another cause of intraorbital pulsating tumors has been suggested by Collard, viz., paralysis of the vaso-motor nerves of the ophthalmic artery, allowing this vessel and its branches to become inordinately dilated.

SYMPTOMS.—When the disease is aneurismal its appearance is generally sudden, the patient being conscious at the time of a sharp crack, as if something had given way behind the orbit, accompanied sometimes by an acute

* De la Communication de la Carotide interne et du Sinus caverneux, 1870; American Journal of the Medical Sciences, July, 1864.

† Medico-Chirurgical Transactions, vol. xlii.

‡ American Journal of the Medical Sciences, April, 1865.

§ British Medical Journal, 1875, vol. i.

pain in the same region. The vessels of the palpebral conjunctiva soon become involved, sometimes to a degree amounting to chemosis; loud sounds, tumultuous and other harassing sensations, are experienced in the head, described by the patient as roaring, whizzing, blowing, or forging; the eyeball becomes prominent (Figs. 399 and 400), a distinct pulsation can be felt in the orbit, and on auscultation an aneurismal bruit can be heard over the side of the head and over the orbit. When the circulation through the common carotid is arrested by pressure, all pulsation and sounds disappear. Frequently there is a convergent strabismus, or there may be paralysis of the third, fourth, and sixth pairs of nerves, with defective vision, and finally entire loss of sight, in consequence of extensive structural changes, the result of inflammatory congestion affecting the humors and tunics of the organ.

Fig. 400.

Intraorbital aneurism by anastomosis, involving the side of the head and face, in a man twenty-five years of age. Appeared soon after birth.—Morton.

Causes.—The causes which are concerned in producing disease of the blood-vessels of the orbit sometimes have a congenital origin; frequently they are traumatic. In the cases collated by Dr. Morton several were traced to a severe injury which had been received upon the head. In Dr. Harlan's case* the man had been struck insensible by a passing car, and remained in a partially unconscious state for almost three weeks. Of 62 cases of intraorbital aneurism collected by Walter Rivington,† 33 were traumatic and 29 idiopathic. The disease, when arising from other than traumatic causes, appears to manifest a preference for the left side, and is more common in females than in males.

Diagnosis.—The signs chiefly distinctive of aneurism and of aneurism by anastomosis, on which some stress has been placed by Dr. Morton, are the following. In aneurism, especially of the diffuse kind,—that is, an aneurism in which the sac has given way and allowed the blood to escape into the surrounding tissues, or where a dilated vessel has been suddenly ruptured,—the invasion of the disease is instantaneous. The patient is conscious of some unusual sound, like the sharp crack of a pistol, which is soon followed by aneurismal sounds in the head, the whirr being synchronous with the diastole of the heart, and accompanied with protrusion and pulsation of the eyeball. In aneurism by anastomosis the disease is more gradual in development, is generally congenital, and although there may be protrusion of the eyeball with pulsation and bruit, the latter is continuous,—that is, coincident with both the systole and the diastole of the heart. There is also less pain and noise experienced in the head.

The result of post-mortem examinations clearly shows, however, that we are not yet in a position to diagnose with certainty these pulsating growths. Pulsation, bruit, thrill, either intermittent or continuous, and the arrest of these at pleasure by controlling the circulation through the vessel of blood-supply, signs which characterize aneurism in other localities, have been shown not to be inconsistent with the existence of aneurism by anastomosis,

* American Journal of the Medical Sciences, July, 1870.
† British Medical Journal, 1875, vol. i.

and indeed may be present without aneurism at all. Nor are the symptoms of exophthalmos less equivocal, whether of sudden or of slow appearance. In some of the cases which were subjected to examination after death, in which there had been a sudden appearance of pulsation and thrill and exophthalmos quickly succeeding an injury received upon the head, and where traumatic aneurism would *a priori* seem most probable, the morbid condition was found to be quite different. All these symptoms may arise from venous or from arterial obstruction, such as embolism of the cavernous sinus, or from pressure on the ophthalmic artery or on the sphenoidal portion of the internal carotid. The influence of inflammation in determining the coagulation of the blood within the vessels should never be lost sight of in cases of intraorbital enlargements following traumatic injuries. The sinuses in the sella Turcica of the sphenoid bone are most favorably situated to feel the effects of concentrated force applied to the temple or the orbit, and a phlebitis of these channels would be as likely to cause an obstruction and coagulum as one in the canals of other veins. This certainly took place in one of Dr. Morton's cases.

TREATMENT.—As long as the disease exhibits no tendency to increase, it is wise to maintain a masterly inactivity, especially as some obscurity must generally attend our diagnosis. The disease may remain for a long time stationary, or may even undergo a spontaneous cure. Our remedies should therefore at first be confined to rest and to digital compression of the primitive carotid. The latter, first employed by Professor Gioppi, may be kept up for two or three hours a day for three or four weeks. In Dr. Harlan's case it was faithfully though unsuccessfully continued from four to six hours a day for a period of five weeks. This method has been used in 16 cases. Three cures have been reported,—one by Professor Gioppi, of Padua, in 1856; one by Scaramuzza,* of Verona, in 1858; and one by Dr. Clarkson Freeman, of Canada. The compression was less successful in traumatic than in idiopathic cases. Should compression fail, and the progress of the disease be such as to demand operative interference, resort may be had either to injection or to the ligature of the common carotid. Dr. Noyes, of New York, has reported six cases of cure by the first method.† The agents used were in two cases tannin, in one the lactate of iron, and in three the perchloride of iron. The case treated by the lactate of iron was under the care of Dr. Brainard, of Chicago, and is the more remarkable from the fact that the carotid had been previously ligated without success. In instances of erectile tumors, if the diagnosis could be certainly established, the use of Monsel's solution of iron would promise a successful result; but if the growth should prove to be aneurismal, the same evil might result from the introduction of a coagulating fluid as sometimes follows the sudden formation of clots in aneurisms elsewhere. The subcutaneous injection of ergot in one case by Socin was believed to have aggravated the disease.

Ligation.—Intraorbital vascular growths may be attacked by the ligature in two ways: first, by tying the common carotid; secondly, by strangulation within the orbit.

Ligation of the common carotid.—The results of this operation have been remarkably successful. Up to 1861, 20 cases of intraorbital aneurism were reported‡ by Mr. Ernest Hart, 14 of which were cured by ligation of the primitive carotid, 2 were partially cured, 1 was unsuccessful, and 3 died. Dr. Morton,§ in 1865, collated 34 cases of the disease. In 30 the carotid was tied, with the following result: 22 of the patients were cured, 3 were relieved, in 2 the operation proved unsuccessful, and 3 died. In 1875, Rivington gave a résumé of 62 cases of intraorbital aneurism. In 46 of these the primitive carotid was ligated, the right vessel twenty times and the left twenty-six times; 18 of 44 cases were idiopathic, and 26 were traumatic. Of the idiopathic cases, 12 were affected on the right side and 6 on the left, and of this number

* Lancet, 1862, vol. i. p. 274.

† New York Medical Journal, March, 1869.

‡ Lancet, 1862, vol. i. p. 273.

§ American Journal of the Medical Sciences, April, 1865.

15 recovered and 3 died; of the 26 traumatic cases, 23 recovered and 3 died; making a total of 44 cases, with only 6 deaths. Among the 38 returned as recoveries, 26 were perfect cures, 7 were partial cures, and 5 were failures. In a number of the successful cases the vision of the patient was recovered.

Strangulation.—In order to produce the strangulation of a mass of diseased vessels within the orbit, it will be necessary to divide the external commissure of the palpebral muscle along with the reflexion of the conjunctiva from the globe of the eye to the lids, and, after retracting the parts widely, to slip a noose of strong hemp cord over the ball, and, pushing it down between the walls of the orbit and its contents by means of the fingers or by forked probes, to draw the ligature sufficiently tight to strangulate effectually the included structures. This plan would be proper only in cases where the eye was hopelessly disorganized. Strangulation might be performed for a circumscribed erectile or other growth within the orbit by exposing the latter cavity, temporarily displacing the eyeball, and encircling with a ligature. Mr. Lansdowne,* on the 18th of February, 1874, opened the orbit in a case of varicose aneurism of that cavity, and successfully applied a catgut carbolized ligature on both sides of the tumor. The patient was perfectly cured. In one of Dr. Morton's cases the orbit was boldly opened, the erectile growth enucleated, and the hemorrhage arrested by the actual cautery and by pressure.

Galvano-puncture has been applied in two instances without success; in one treated by Pétrequin the patient died. The result was thought by Holmes to be due to this treatment.

Medical treatment.—Dr. Holmes, of Chicago,† in a case of intraorbital tumor following an injury, secured success by the use of veratrum viride and Squibb's fluid extract of ergot four times a day for nine weeks. Galezowski‡ succeeded, by the internal use of the iodide of potash and intermittent pressure, in so far removing the protrusion of the eye and the abnormal sounds that at the time of his report little doubt remained that the cure would be made complete.

Arterio-Venous Aneurism of the Carotid Artery and the Internal Jugular Vein.

An inflammatory adhesion of the walls of the carotid artery and the jugular vein, and the subsequent communication of their channels by ulceration, have, in some instances, followed gunshot and punctured wounds of the neck. A soft, bluish, compressible swelling, with a strong, blowing, continuous sound and purring tremor, the sound strongest during the cardiac systole, indicates the nature of the disease.

A peculiar ectasis of the external jugular vein is occasionally seen, which is always the result of injury. It commences in the vessel just before or after it has crossed the sterno-cleido-mastoid muscle, forming a circumscribed saccular dilatation of the vein, attaining the size of a hickory-nut or a walnut, without pulsation or thrill. I saw a well-marked example of the affection in a patient who once came to my clinic at the University of Pennsylvania; and my friend Dr. Mastin, of Mobile, was kind enough to send me the photograph of a similar case which occurred in his practice, the disease coming on several months after a gunshot wound of the neck.

Treatment.—Arterio-venous varix of the neck requires no operation. It demands little attention other than the application of pressure by a compress and adhesive straps. The disease manifests little disposition to increase, and may undergo a spontaneous cure. In the venous ectasis, or varix, the swelling gradually disappears under pressure.

Aneurism of the Axillary Artery.

The position of the axillary artery is one which, independent of observation to the contrary, would appear to be most favorable to the formation of

* British Medical Journal, June 5 and 26, 1875.

† American Journal of the Medical Sciences, p. 44, July, 1864. ‡ Gazette des Hôpitaux, 1871.

aneurism. In its course through the axillary space it is loosely imbedded in glandular and cellulo-adipose tissues, and is subjected by the varied and forcible movements of the upper extremity to all conceivable flexures, and consequently to great strain. Indeed, its location and the various disturbances to which it is exposed, notwithstanding the great mobility of the shoulder, render this vessel weaker in its defenses against injury than the popliteal. Yet, on comparing aneurism of the axillary with the same disease in other vessels, it is found to occur only about once in every thirty-one cases. For example, in Crisp's collection of 551 aneurisms of various vessels, 18 were axillary. The disease is most common on the right side, arising doubtless from the more general use of the right arm, and occurs in males oftener than in females. The disparity in this respect between the sexes appears to be more marked in the disease under consideration than in other external aneurisms. In 18 cases of aneurism of this vessel recorded by Mr. Crisp,* there were 17 males and 1 female; in 37 cases noticed by Mr. Erichsen,† only 3 were in females. Both axillary arteries are sometimes simultaneously affected.

Symptoms.—In spontaneous aneurism the symptoms are gradually developed. There is first a small tumor, which may not exceed a marble in size, and which as it enlarges may be discovered, according to the portion of the vessel involved, immediately below the clavicle, in a little space formed by the divergence of the deltoid and the clavicular portion of the pectoralis major muscles and occupied by cellular tissue and the thoracic acromial blood-vessels; or the tumor may project lower down, raising the pectoral muscles into a prominence; or, if lower than where the artery is crossed by the pectoralis minor muscle, it may develop towards the cutaneous surface of the axilla. The pulsations and thrill increase in intensity as the growth enlarges. In consequence of the relation of the artery to the axillary plexus of nerves and to the veins of this region, pressure-effects soon become manifest. The limb and shoulder are rendered stiff, and their movements restrained; the muscles become greatly enfeebled; severe pain is experienced down the arm, along the side of the chest, and upward and outward on the shoulder and in the neck; the arm becomes swollen from pressure on the axillary vein and its branches, and the pulse fails at the wrist. As the tumor acquires bulk it may displace the clavicle, pushing it upward and forward, or, by coming in contact with the side of the thorax, it may cause the destruction of a portion of the upper ribs, and, in rare instances, may enter even the cavity of the chest.

Diagnosis.—The diseases which resemble in some degree axillary aneurism are *encephaloid cancer*, *glandular enlargement*, *abscess*, and *cysts*. In none of these is there pulsation or thrill; in none is the size of the tumor influenced by pressure upon the subclavian artery; and in none is the pain or the disability of the arm comparable to that experienced in aneurism of the axillary artery. In malignant growths commencing in the upper extremity of the humerus, the resemblance to aneurism is often very striking. In a patient who applied for admission to the University Hospital, the tumor was soft, and the pulsation and bruit were very distinct, disappearing when the subclavian artery was firmly pressed upon, and promptly returning when the pressure was removed. The following peculiarities, however, served to make the diagnosis clear: the tumor, though soft, was elastic; it had received its form from the deltoid, projecting both in front of and behind that muscle, in which situations it was observed at the commencement. An axillary aneurism could not occupy such a locality. In addition to this, the amount of pain and disability in the arm was much less than is usual in aneurism.

Progress.—Axillary aneurism, when allowed to take its course without interference, usually terminates, after great suffering, in death from hemorrhage by rupture of the sac, from gangrene of the limb, or from constitutional irritation. In a very few cases the disease has undergone spontaneous cure.

Treatment.—In the treatment of axillary aneurism, rest, diet, flexion, and

* Diseases of the Blood-Vessels, p. 213. † Surgery, vol. ii. p. 122.

pressure, when the latter can be applied, should take precedence of all other measures. A conical compress placed in the subclavian fossa, and kept in position by the fingers of a corps of assistants for two or three hours each day, should be tried for some time, assisted by flexion of the arm, the latter being raised and carried across the back of the neck to the opposite side. By the hypodermic use of morphia, or by an anæsthetic, the pressure and the constrained position can be made endurable. Dr. Middleton Goldsmith succeeded in effecting the cure of an axillary aneurism* by distal pressure kept up for seven weeks, during the last four weeks of the treatment antimony and digitalis being given; but I believe this to be the only case of aneurism cured by hygienic, medical, or compressory measures. A combination of these with flexion would be well worthy of a trial.

Ligature.—The usual method of attacking axillary aneurism is by deligation between the sac and the heart, after both the Hunterian and the Anel method. By the first plan the ligature is placed around the third part of the subclavian. By the second plan the artery is tied immediately below the clavicle, above the pectoralis minor muscle. The first is to be preferred for several reasons: by its adoption the surgeon will be more likely to expose a sound portion of the vessel, will interfere less with the collateral circulation, and will encounter less difficulty in effecting his object. The mortality following the ligation of the subclavian will appear from the following record of cases made by different writers. Of 27 cases of axillary aneurism analyzed by Professor Gross† in which the subclavian artery was tied, 17 recovered and 10 died. Mr. Erichsen,‡ in 48 cases of spontaneous aneurism of the axillary for which the subclavian was tied, found 23 recoveries and 25 deaths. Professor Parker furnishes 57 ligations of the subclavian for idiopathic aneurism of the axillary, and 24 for traumatic. Of the former, 21 died and 36 recovered; of the latter, 8 died and 16 recovered. In Koch's§ collection of axillary aneurisms, embracing 94 cases, in which the third part of the subclavian was ligated, 51 recovered and 43 died. I find in a collection of 148 cases of aneurism‖ that 21 were axillary. In 16 of the 21 the subclavian was tied in its third part, with 11 cures and 5 deaths. We have here recorded a total of 271 ligations, with 112 deaths and 154 recoveries. The tables of Dr. Norris contain 58 cases of ligation of the subclavian for aneurism, probably not all axillary. Of these 32 recovered and 26 died. Dr. Willard Parker¶ reports 4 unpublished cases of ligature of the subclavian artery for axillary aneurism, 1 of which was traumatic; 3 recovered and 1 died. These statistics are ample enough to show that the operation is one attended with a very high death-rate; but when it is considered that the termination of the disease without interference is uniformly fatal, the duty of the patient is to elect the operation, and that of the surgeon is to execute it with as little delay as possible, after having tried unsuccessfully the medical and mechanical plan already described.

Causes of death after ligation are generally *intra-thoracic inflammation, suppuration of the sac, hemorrhage,* and *mortification.*

Intra-thoracic inflammation.— Erichsen found this to occur ten times in 25 ligations. This is in remarkable contrast with the result given by Norris in his table on ligations of the subclavian, from which it appears that only five times in 69 operations did this prove to be the cause of death. How many of these ligations were done for axillary aneurism I am not able to determine. The inflammation may attack the lungs, the pleura, and the pericardium. There are several explanations for such sequels. It is highly probable that in passing the needle around the artery the pleura may be wounded and the dome of the chest opened. The close relation of the subclavian to the serous membrane of the pulmonary cavity, and the structural

* Boston Medical and Surgical Journal, 1845, vol. xxxiii. p. 537.
† Surgery, vol. i. p. 776.
‡ Surgery, vol. ii. p. 125.
§ Lancet, 1873, vol. ii. p. 443.
‖ Hunter and Griffith's manuscript collection.
¶ New York Medical Record, 1867-68, vol. ii. p. 97.

alterations which are so often met with in cases of aneurism, make such an accident probable even in the hands of the most dexterous surgeon. Extensive disturbance of the structures at the root of the neck, incident to the operation, may cause inflammation and diffuse suppuration, which are liable, by continuity of tissue, to extend into the pleural or the mediastinal spaces: and the same effects may follow as the result of an inflamed and suppurating sac; or a pleuro-pneumonia may be induced by adhesion of the sac to the walls of the chest, and its subsequent ulceration, emptying the contents of the aneurism into the pleural cavity, as occurred in an interesting case recorded by Professor Gross;* or a communication may take place between a suppurating sac and the lung through an intercostal space, and the pus find its way into the bronchial air-passages and be expectorated by coughing. The case of Bullen,† of England, is one in point, and, notwithstanding the occurrence, the patient made a complete recovery. Similar connections between subclavian aneurisms and the lung have been noticed by Neret‡ and by Guthrie.

Suppuration of the sac is of frequent occurrence, sometimes following the operation after the lapse of five or six days, and at other times being delayed for a much longer period. In Morton's case it took place on the thirteenth day;§ and as an example of the latest occurrence of the accident may be cited the patient of B. Cooper,‖ in whom the suppuration followed two months after the ligation. Inflammation and suppuration of the sac, though an exceedingly dangerous event, is frequently succeeded by recovery. Even when followed by hemorrhage, a very uncommon result, the case is not utterly hopeless. In a case of axillary aneurism in the Pennsylvania Hospital, in which the subclavian was tied by Dr. Morton, suppuration of the sac set in, followed by hemorrhage, twenty-four days after the detachment of the ligature. During the thirteen days succeeding the first bleeding the patient had ten hemorrhages. These were controlled by pressure, by Monsel's solution of iron, and, last, by ligation of the subscapular artery. The limb finally became gangrenous, and was removed at the shoulder-joint. The man made a slow but complete recovery.

Hemorrhage, whether from the seat of ligation or from the sac—most frequently from the latter—constitutes the most common cause of death. In Erichsen's list it makes about one-eighth, 3 dying out of 25. In Norris's collection 8 out of the 26 deaths are due to hemorrhage; and in 12 cases which I have recently examined, 4 died from this cause. The accident may take place at any time between the fourth and the thirtieth day.

Mortification of the limb and of the sac.—This may be due to the obliteration, from pressure or from embolism, of one of the chief branches of the axillary concerned in establishing the anastomotic chain, for example, the subscapular, which communicates freely by its dorsal and posterior scapular branches with the supra-scapular and transversalis colli arteries. Or it may arise from the exhaustion consequent upon repeated hemorrhages, as was the case in Morton's patient. The mortification may be partial or extensive, and is not a common sequence of the ligation. It is as likely to follow ligation for traumatic injuries of the axillary as it is to result from the same operation for spontaneous aneurism. In Professor Gibson's case¶ of mortification of the hand and forearm, the subclavian was tied for a rupture of the axillary artery occasioned by forcible attempts to reduce an old luxation. In Hospel's case,** the death of the arm succeeded the ligation of the subclavian, in consequence of a wounded axillary artery. The only four cases where mortification followed deligation for true axillary aneurism are those of Colles,†† Blizard,‡‡ Brodie,§§ and Morton. Mortification of the sac is quite

* Surgery, vol. i. p. 776.
† London Medical Repository.
‡ Norris's Contributions to Practical Surgery, p. 230.
§ American Journal of the Medical Sciences, July, 1867, p. 70.
‖ Ibid., vol. ii., 1828.
¶ Gibson's Surgery.
** Gazette des Hôpitaux, 1839.
†† Edinburgh Medical and Surgical Journal, vol. xi.
‡‡ Hodson on the Arteries.
§§ London Medical and Physical Journal, vol. ii., New Series, 1827.

uncommon; in only two of the 56 cases recorded by Norris did this take place.

Treatment.—There are, perhaps, no complications which cause so much anxiety to the surgeon as the various accidents to which an aneurismal sac is exposed. Should suppuration ensue, it is best, as soon as fluctuation and pointing are well established, to open the abscess and discharge its contents. If this should be followed by moderate hemorrhage, a careful examination must be made to detect the particular branch from which the bleeding proceeds, and, if successful, secure it at once by a thread. If the hemorrhage comes in a gush, the first thought must be to prevent the patient from being immediately destroyed by the flow. The sac should be at once plugged by strips of lint, or whatever may be at hand: as long as this measure is sufficient to arrest the bleeding the surgeon may be content. The next critical period will attend the removal of the tampon, which, as it becomes foul with the discharges, must be gently dislodged in the course of five or six days. If at this time the hemorrhage is renewed, the limb should be promptly removed at the shoulder-joint.

The sac is sometimes the subject of suppurative inflammation antecedent to any surgical treatment having been adopted for the cure of the aneurism. Under such circumstances the tumor becomes swollen, tense, tender, and inflamed, with swelling and severe pain in the arm. The case admits of no delay. The subclavian should be exposed and tied in the third part of its course.

Syme on one occasion slit open an axillary aneurism while the subclavian was compressed against the first rib, turned out its contents, and tied the vessel on the proximal and distal sides of the sac. To execute such a task demands a degree of cool deliberation and surgical address which is not possessed by every operator.

Rupture of the sac.—When the walls of the sac become much attenuated they are liable to give way and to allow the contents to escape into the adjacent parts, forming a diffused aneurism. Ligature of the subclavian in such an event should be performed at once.

Aneurism of the Brachial Artery and of its Branches.

In only a single instance have I witnessed a spontaneous aneurism of the brachial artery. The patient was about sixty years of age: the tumor was situated two inches above the bend of the arm, and had attained the size of a pullet's egg. No cause could be assigned for its existence, and the inference that it was an example of true or spontaneous aneurism seemed to be legitimate. The artery was tied two inches above the tumor, with entire success. The tables of Crisp contain no case of such an aneurism. In Liston's case, mentioned by Crisp, in which a pulsating swelling appeared at the bend of the arm after a severe muscular effort, the cause was most probably traumatic. A few scattered cases may be found in the writings of Pelletan, Scarpa, Flajani, Pilcher, and Desault. In the forearm, aneurisms of the radial and ulnar arteries have been observed by Sir Astley Cooper, De Morgan, Todd, and Erichsen. Crisp mentions one connected with the inferior part of the radial artery among the collection of Langstaff, in the College Museum; and I have met with one situated at the lower portion of the ulnar in a young woman.

Traumatic aneurisms are quite common, especially in the arteries of the forearm: they have, in connection with arterio-venous aneurism, been already considered.

Treatment.—The treatment of a case of spontaneous aneurism affecting the brachial, radial, or ulnar arteries differs in no respect from that proper to the disease in other vessels. Pressure, supplemented by flexion, should be first tried, when the disease exists in the forearm, and if these means fail a ligature must be applied: in the case of brachial aneurism, the thread must be placed on the artery above the tumor, and in aneurism of the radial or the

ulnar, on both the proximal and distal sides of the sac, without disturbing its contents. Langenbeck cured a case of aneurism of the radial artery in twenty-four hours by an injection of ergotin. When the tumor is situated on the brachial, near the bend of the arm, it is not advisable to adopt the Hunterian plan, by making the ligation a considerable distance from the disease, but rather to choose that of Anel, by tying nearer to the sac, in order that the thread may include that portion of the vessel which is below the anastomotica magna, and thereby render the restoration of the blood through the collateral vessels to the forearm more certain. Should mortification follow the ligature of the brachial, amputation will become necessary.

Aneurism of the Abdominal Aorta.

The abdominal aorta is not so commonly the subject of aneurism as the thoracic part of the vessel. Males are more frequently affected than females. Of 59 cases of the disease, 51 were males and 8 females.* The largest number of cases occur between the thirtieth and the fortieth year of life. These tumors generally appear at that portion of the artery where the cœliac axis is given off, and often acquire an enormous bulk. It has been thought that the vessel is weaker at the place where the first abdominal branch arises; but I have never been able to discover that the arterial walls at this point are thinner than elsewhere. There are, however, two points worthy of notice in connection with this portion of the vessel, and which, I doubt not, exercise a determining influence in thus localizing abdominal aneurism. Where the aorta enters the ventral cavity, between the pillars of the diaphragm, it is arched over by a tendinous band, which prevents, by its inelasticity, the dilatation of so much of the vessel as is covered by its fibres, and produces a constriction in its walls at each ventricular systole. About one inch and a half below, the artery becomes suddenly contracted, giving to this part of the vessel a pouch-like form. The mechanical effect of this peculiarity is to enlarge by blood-pressure this portion of the aorta to a greater degree than elsewhere. Occasionally the disease is seen lower down in the vessel (Fig. 401), a position well adapted to the treatment by compression.

Fig. 401.

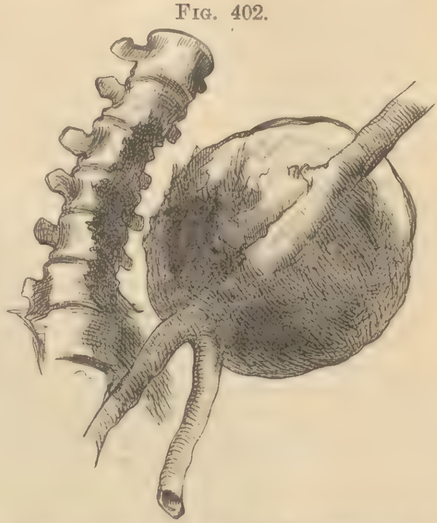
Aneurism of the aorta near its bifurcation.—From a preparation in the Museum of the University of Pennsylvania.

Symptoms.—Aneurism of the abdominal aorta usually begins with a dull, localized pain, which, as the disease advances, becomes darting, gnawing, or tearing. If the parietes of the abdomen are thin, or if they are thoroughly relaxed by drawing up the lower extremities and elevating the shoulders, a tumor may be discovered by a digital examination made over the epigastric region. Generally, however, the hand recognizes a distinct pulsation, and the ear, when applied either over this part of the abdomen or on the opposite side of the trunk, over the spine, will discover a loud *bruit de soufflet* or bellows sound, but never a diastolic murmur. The aneurism rarely enlarges in a median direction at first, but inclines to the left side, the one in which there is the least resistance from surrounding organs, and which answers to the general relation of the artery with the spinal column. When the sac becomes very large there is not an organ within the abdominal cavity which may not be disturbed by the pressure of the growth. The functions of the stomach often become deranged, giving rise to vomiting; the urinary secretion, at first increased, may finally be suppressed; the bile may be prevented from passing along the excretory ducts of the liver, and the patient is rendered icterode; the intestines sometimes become distended with gaseous or fæcal accumulations,

* Crisp on Diseases of the Blood-Vessels, p. 161.

causing severe flatulent colic or obstinate constipation. The constant pounding of the tumor against the spinal column and the ribs is frequently followed by erosion of the vertebræ and weakness of the lower extremities from pressure upon the spinal cord. (Fig. 402.) This change is usually going on when the patient complains of severe gnawing or boring pains in the back. Altogether, the suffering and disability are much less in abdominal than in thoracic aneurism, as the tumor in the former has ample room for enlarging, and the contents of the abdomen are neither so fixed in position nor so immediately essential to life as are those in the middle and posterior mediastinal regions. Hence it is not unusual to find persons suffering from abdominal aneurism pursuing their occupations until the disease is far advanced in its course. A boatman, who was at one time under my care, suffering from a large ventral tumor of this kind, insisted upon following the duties of his position almost throughout the entire course of the disease; and I have already alluded to another case, that of an itinerant peddler, who, notwithstanding the fact that his aneurism is so large as to compel him to throw his body considerably to the right side in order to preserve an equilibrium, continues to ply his avocation with a diligence which is truly marvelous in one between whom and instant death there is but a step.

Fig. 402.



Abdominal aneurism in which the bodies and articular processes of three dorsal and one lumbar vertebræ were destroyed, and the sheath of the spinal cord exposed and thickened.

Diagnosis.—The morbid conditions liable to be confounded with abdominal aneurism are *tumors* and *enlargements* of the different organs within the ventral cavity, and *abnormal pulsation of the aorta.* With reference to enlargement of the glandular organs, carcinomatous or otherwise, within the splanchnic cavity, much may be learned from the regional position occupied by the swelling, especially at the commencement of the trouble. The fact that aneurism is generally median, and in the epigastric space, would serve to distinguish it from hepatic, splenic, and renal enlargement, which would first appear respectively in the right hypochondriac, left hypochondriac, and lumbar regions. The left lobe of the liver does extend somewhat across the median line to the left side; but the superficial character of the swelling when this part of the organ is implicated, and the continuation of the line of dull percussion across from the right lobe, aside from other signs, are features which do not belong to aneurism. In malignant diseases of the stomach, pancreas, omentum, or other parts within the abdomen there is generally a previous history of disturbed digestion and of gradual loss of flesh and strength, and frequently a pronounced cachexia is written on the face. The tearing or boring pain of aneurism does not belong to other abdominal growths. Pulsation, one of the common attendants of aneurism, may accompany ventral disease, sometimes being transmitted through the tumor by its contact with the aorta, and at other times being due to an inherent vascularity of the growth. In the tumor the movement is one of upheaval, in which the mass itself is passive, while in aneurism the force is recognized as internal to the swelling, and expansive. In encephaloid disease, owing to the rich supply of blood-vessels, and to softness of texture, not only does the pulsation very closely resemble aneurism, but often also a distinct murmur is present, which will render the

diagnosis more difficult. When malignant disease begins in the lumbar glands, the destruction of the vertebræ may follow, as in aneurism, and the same gnawing, deep-seated pains may be experienced as when the bones are attacked in the latter affection. In cancer, however, the pulsation is never so strong as in aneurism, and the murmur is more soft and continuous.

The condition most frequently mistaken for aneurismal dilatation is that *abnormal pulsation of the abdominal aorta* which is peculiar to nervous and anæmic females and sometimes to males. In this singular affection of the artery there is rarely any pain, there is no single rough sound as in aneurism, and the age and constitutional peculiarities of the patient are different from those which characterize subjects of the latter disease.

Termination.—Aneurism of the abdominal aorta in most instances terminates by opening into the peritoneal or retro-peritoneal space, this being followed by extensive extravasation of blood and the signs of internal hemorrhage. Occasionally the patient dies from a failure of the functions of nutrition, most probably caused by pressure on the thoracic duct or the mesenteric glands. The sac may also open into the intestinal canal, into the thorax, into the mediastinum, or into the ascending vena cava. Of 59 cases of aneurism of the ventral aorta,* 11 opened into the retro-peritoneal space, 10 into the cavity of the peritoneal sac, 5 into the left pleura, 3 into the vena cava inferior, 1 into the lung, 1 into the colon, 1 into the pelvis of the kidney, 1 into the posterior mediastinum, 1 into the chest; 2 died suddenly without rupture of the sac, and 2 perished from jaundice. Of the remaining 21, 9 died from disease of the lungs, the liver, or the heart, or from other affections more or less directly connected with the aneurism, and in 12 the terminations were not stated.

Treatment.—The treatment of aneurism of the abdominal aorta consists for the most part in rest, a restricted diet, and the internal use of the iodide of potash and the tincture of veratrum viride. The latter should be administered in doses sufficient to lessen the force and frequency of the heart's action. If the pain is severe, opium in some of its forms may be freely used; and to remove colicky or flatulent distention of the intestines, carminatives, such as the compound tincture of cardamom, or turpentine, should be administered. The latter is best given in the form of an injection. Sometimes the disease is situated sufficiently low in the aorta to admit of surgical treatment. In 1864, Murray, of Newcastle-on-Tyne, tried for the first time instrumental compression, and with entire success. The pressure was made by a tourniquet applied over the abdominal walls on the cardiac side of the tumor, and after a second application, the patient being under chloroform, the cure was effected in five hours.† A very interesting feature connected with this case, one which may embolden over-sanguine surgeons to renew their attempts at ligating the abdominal aorta, is the completeness with which the collateral circulation was established after the consolidation of the aneurism. The death of the patient several years after, from another aneurism of the aorta, near to the foramen aorticum in the diaphragm, and too high up to admit of pressure, enabled the surgeon not only to verify, by an examination of the body, the correctness of the diagnosis and the cure of the original disease, but also to exhibit the vessels which had substituted the obliterated trunk of a portion of the aorta in the work of transmitting the blood to the intestines and the lower parts of the body. These were the colica media of the superior mesenteric, with the colica sinistra of the inferior mesenteric and with the colica sigmoidea and hemorrhoidal arteries; the ilio-lumbar by its ascending branches with the superior lumbar, and by its descending branches with the circumflex ilii from the external iliac artery. The parietal arteries which participated in this work were the internal mammary, the intercostals, and the lumbar, with the superficial and deep epigastric and the circumflex iliac vessels.

Since the introduction of this method as an established surgical procedure in the treatment of aneurism of the abdominal aorta, a number of

* Crisp on Diseases of the Blood-Vessels, p. 163.

† Lancet, February 8, 1873.

supposed cases of the disease have been from time to time represented as cured. Among these is the one of Heath, of Sunderland,* in which the tumor is said to have been consolidated in twenty minutes after the second application of the pressure. Such precedents are quite sufficient to warrant the application of compression whenever the situation of the tumor will allow it. The instrument best adapted to effect the pressure is the tourniquet of Lister, already figured under "Hemorrhage" (p. 162). This instrument surrounds the body, and should have a roller about two inches wide attached to the pad, in order that the force may be accurately concentrated on the artery above the tumor, and that no more of the abdomen be compressed than is absolutely necessary for the purpose. Particular attention should be given to these points, as much damage has been done to the different viscera and to the solar plexus of nerves, sufficient in a number of cases to cause the death of the patient. The pressure should be carried to the extent of arresting the current of blood through the vessel as completely as possible, and may be continued, if the pulse remains good, for four or five hours, the patient being kept during this time under the influence of an anæsthetic or of morphia hypodermically administered. If the treatment is not well borne, it will be better to apply the compression for half an hour or an hour daily, keeping the patient perfectly quiet on his back in the intervals, until the success or failure of the method shall have been determined.

Spontaneous cures of aneurism of the abdominal aorta have been noticed by writers. In one case which I had under observation for some time, and in which I am very confident the diagnosis was correct, this event took place.

Aneurism of Certain Branches of the Abdominal Aorta.

The arteries within the abdomen, besides the aorta, which have furnished examples of aneurism, are the superior and inferior mesenterics, the splenic, the hepatic, and the renal. An aneurism of the right ovarian artery has been recorded by Whitemarsh.†

In 39 cases collected by Lebert, the superior mesenteric and the splenic were each affected 10 times; the hepatic and its branches 8 times; the cœliac and the inferior mesenteric each 3 times; the renal twice;‡ and in 3 cases the aneurisms were multiple. These aneurisms do not attain any great bulk, seldom exceeding the size of a hen's egg, and are usually round or oval in shape. Except when connected with the hepatic, the renal, or the cœliac axis, they are movable, changing their position in the various actions of the body. They possess, also, the characteristics of pulsation and bruit. When the cœliac artery is affected, the disease cannot be distinguished from aneurism of the parent trunk.

In cases of implication of the hepatic artery, the pressure-effects of the tumor give rise to pain in the right side, and to jaundice from obstruction of the hepatic, cystic, and common bile ducts. The disease may exist without ever being suspected, so trifling is the inconvenience sometimes experienced; though in a number of instances severe pain has been felt in the back. These tumors, like aneurisms elsewhere, terminate by rupture of the sac, causing death from hemorrhage.

The diagnosis of such an aneurism must necessarily be attended with much uncertainty; but if a floating tumor can be detected through the parietes of the abdomen, having the characteristic pulsation and sounds of aneurism, the operation of opening the ventral cavity and ligating the artery on the cardiac and distal sides of the sac will be entirely justifiable.

Aneurism of the Primitive Iliac Artery.

Aneurism of the primitive iliac alone is exceedingly rare. The tables of Crisp contain only two examples of aneurism of this artery out of 551 cases

* British Medical Journal, October 5, 1867. † Ibid., 1867, vol. ii. p. 177.
‡ Ziemssen's Cyclopædia of the Practice of Medicine, vol. vi. p. 439.

of the disease. Both of these were in males, the one under the care of Adams, and the other occurring in the practice of Murray, of the Cape of Good Hope. Both were on the right side. The one under Adams proved to be a varicose aneurism, as it communicated with the accompanying veins. Both proved fatal,—the first without any surgical interference, and the second after deligation of the abdominal aorta by Murray.

Aneurism of the Internal Iliac and its Branches.

No case of aneurism invading the internal iliac is mentioned by Crisp. Sandifort has recorded one. The branches of the internal iliac most commonly affected are the gluteal and the ischiatic. Mr. George Fischer* has collected 35 cases of such lesions. Of 25 of these, which were gluteal aneurisms, 11 were traumatic and 14 spontaneous; and of the 6 which were known to be ischiatic, 2 were traumatic and 2 spontaneous; while of 2 which were doubtful,—that is, in which it was uncertain whether they were gluteal or ischiatic,—1 was traumatic and 1 was spontaneous. The remaining 2 were anastomosing aneurisms. Of the 14 traumatic, 5 were diffused, 7 circumscribed, and 2 varicose; 12 of them were caused by punctures, 1 by a shot wound, and 1 by getting into a saddle. Of the 21 spontaneous, the cause was uncertain in 11; in 9 it was believed to be from previous contusion, and in 1 it was associated with a fracture of the pelvis. As regards sex, 28 were males and 7 females. All the traumatic cases were in males. Those which had a traumatic origin occurred between fourteen and fifty years of age, and of those which were spontaneous, 10 out of the 17 were between twenty-one and fifty.

To distinguish between a gluteal and an ischiatic aneurism is not always possible. The gluteal, from the anatomical position of the artery, is usually farther back in the buttock, while the ischiatic appears downwards and forwards towards the gluteo-femoral crease.

Symptoms.—The presence of a pulsating compressible tumor in the gluteal region, having a distinct bruit, with pain extending over the nates and down the thigh, and accompanied with lameness in the corresponding limb, is an indication of either gluteal or ischiatic enlargement, especially if there is an antecedent history of a wound or of some pelvic injury.

Diagnosis.—The diseases which most resemble gluteal or ischiatic aneurism are abscess, cancer, and ischiatic hernia. The exploring-needle would determine the existence of a purulent accumulation. To differentiate the disease from cancer is a more difficult task, sometimes an impossibility. The internal iliac artery has been twice tied, once by Guthrie and once by Morton, for supposed gluteal aneurism which afterwards proved to be encephaloid disease. In carcinoma the increase of the tumor is more rapid than in aneurism, especially when the disease is spontaneous, the only form, indeed, in which any mistake is likely to occur. The antecedents of the patient, and the general state of his nutrition, may also furnish some light which will serve to assist the surgeon in establishing the true character of the disease. In ischiatic hernia the absence of pulsation and of sound, with the resonance of the tumor, ought to be sufficient to prevent such a swelling from being confounded with aneurism.

Treatment.—In the traumatic form of these aneurisms the swelling should be freely laid open, and both extremities of the wounded vessel secured by ligatures. In 6 of Dr. Fischer's† cases of traumatic gluteal aneurism treated in this way, 4 recovered, 1 died from hemorrhage, and 1 failed. Davidge, of Maryland, and Dr. George McClellan, of Philadelphia, each tied, with success, the gluteal artery for aneurism. Dr. L. A. Dugas, of Georgia,‡ on March 16, 1857, tied the ischiatic artery for aneurism of that vessel. In consequence of secondary hemorrhage, Dr. Wm. J. Holt, on the 26th of the same month,

* British and Foreign Medico-Chirurgical Review, vol. xlvii., 1871. † Ibid.
‡ Southern Medical and Surgical Journal, New Series, 1859, p. 651.

ligated the common iliac artery. The patient died from exhaustion three days after the operation. M. C. Sappey, Agrégé of the Faculty of Medicine of Paris,* previous to the operation of Dugas, tied the ischiatic artery for aneurism. Though the patient recovered from the operation, the disease was not cured. Professor George W. Campbell, of McGill University, Montreal, in a case of traumatic aneurism of the buttock, caused by a sharp-pointed piece of iron heated to a white heat, tied successfully the gluteal artery without opening the sac.† In order to control the bleeding during such an operation, the abdominal artery should be compressed by the Lister tourniquet.

In spontaneous aneurism of these vessels, pressure of the ventral aorta should be first tried, and if this fail, the ligation of the internal iliac will be required. This vessel has been tied for aneurism of the gluteal and the ischiatic arteries, spontaneous and traumatic, thirteen times, with 6 cures and 6 deaths; in 1 the termination is uncertain.

Of 3 cases in which the common iliac was ligated for the same disease, all died.

Galvano-puncture has been used for the cure of gluteal aneurism by Blasius,‡ but without any beneficial effect.

Aneurism of the External Iliac Artery.

Of 551 cases of aneurism contained in the tables of Crisp, 9 only were connected with the external iliac artery, all of which were in the persons of males. As in aneurism of other vessels, the disease is most common between the ages of forty and fifty. The situation of the external iliac artery is such that it is not readily reached through the abdominal parietes by manual examination, and from this circumstance the diagnosis of tumors in the course of this vessel is often a matter of difficulty. Guthrie tied the common iliac for what he supposed to be an aneurism of that artery. The death of the patient eight months afterwards disclosed the fact that no disease whatever of the vessel existed, and that the tumor was an encephaloid. In a case under the care of Post, of New York, the fluctuation was so distinct that an incision was made into the swelling, under the impression that pus was present. A subsequent hemorrhage established its aneurismal character. Stanley tied the common iliac for a supposed aneurism of the external iliac: the patient died three days afterwards, and upon an examination of his body the tumor was found to be encephaloid.

Symptoms.—In aneurism of the external iliac, a tumor can be recognized through the abdominal walls in the course of the vessel as it passes along the brim of the lesser pelvic basin. That the examination may be made satisfactorily, the ventral walls should be relaxed as much as possible by placing the patient in the recumbent position, with the shoulders elevated and the lower limbs drawn up towards the body. In this posture the outlines of the swelling may be made out, and if it is aneurismal its expansive pulsation may be felt, and the bellows murmur and the thrill recognized by the ear. When the aorta or the common iliac is compressed, both pulsation and thrill in the tumor cease, but are promptly renewed on withdrawal of the pressure from the artery above. As the aneurism enlarges it occasions considerable pain in the groin, along the crest of the ilium, and in the front of the thigh. The patient becomes unable to straighten the limb, and in walking leans forward in order to relieve the psoas magnus and the iliacus internus muscles from pressure.

Diagnosis.—The difficulties which the surgeon sometimes encounters in distinguishing aneurism within the pelvis from other morbid growths in this region, are due to the faithfulness with which all the signs of the former

* Revue Clinique, Paris, 1850; from the Southern Medical and Surgical Journal.
† Published in pamphlet form.
‡ Deutsche Klinik, 1859, p. 165.

affection can be simulated by medullary cancer. When the latter disease originates in the lymphatic glands which lie along the course of the iliac artery, it may completely surround the vessel, which relation, in connection with the soft nature and the great vascularity of its substance, will cause both pulsation and aneurismal murmurs. Even in the absence of pulsation and thrill, the existence of aneurism is not excluded, for the solid contents of such a tumor may accumulate to such a degree as to render the throb and bruit inappreciable by the touch or to the ear. It is only by a careful investigation of all the circumstances attending the origin and the progress of the case that a safe conclusion can be reached. In pursuing such an inquiry, the questions most pertinent to the occasion would be the following: Did the local pain or inconvenience experienced appear suddenly, and during some unusual muscular strain? were the phenomena of pulsation and of bruit present in the incipiency of the disease? have the pain and helplessness of the limb been steadily increasing? has the patient retained his flesh? is he free from any expressed cachexia? does the tumor materially lessen in size when the circulation is arrested in the iliac or in the aorta? has the person affected passed his fortieth year of life? If these interrogatories are answered in the affirmative, there will be a strong presumption that the disease is aneurismal.

Iliac aneurism, when left without interference, though it may undergo a spontaneous cure, will in most instances terminate fatally in eight or twelve months, by the rupture of its sac and hemorrhage; or in consequence of the pressure of the tumor upon the companion vein, and the obstruction to the passage of the blood through the aneurism to the parts below, destroying the vitality of the limb and causing it to mortify.

Treatment.—Aneurism of the external iliac should be first treated by instrumental compression, applied to the abdominal artery by means of the Lister tourniquet, the patient being kept under the influence of an anæsthetic or under that of morphia hypodermically given, during the progress of the treatment. In an aneurism of the external iliac as large as a child's head, I succeeded in effecting a perfect cure by this plan, by two treatments. The first continued for two hours under ether one day, and the second for half an hour, without the anæsthetic, on the day following. The circulation can be controlled much more perfectly by compressing the abdominal aorta opposite the umbilicus, than by acting upon the common iliac. Dr. R. J. Levis was equally successful, by instrumental compression of the external iliac, in curing in six hours a case of ilio-femoral aneurism; and a like result was obtained by Dr. Nichols, of New Orleans, by means of digital compression.

Ligature.—Should compression fail, it will be necessary to resort to the ligature, applied to the external iliac above the sac, or to the common iliac when the disease is near to the latter artery. If from any cause the above operation is not feasible, the external iliac may be tied on the distal side of the sac; and in such an event the thread should be placed on the vessel above the origin of the deep epigastric and circumflex iliac branches. Deligation of the external iliac for aneurism of this vessel may be considered a promising operation. Of the 9 cases of external iliac aneurism which are recorded by Crisp, 4 were treated by this plan, and all recovered. The tables of Dr. George Norris* contain 97 cases of ligature of the external iliac artery for aneurism, 71 of which were cured and 26 died. Cutter† has collected 30 cases of ligation of this vessel for aneurism, with 19 cures and 11 deaths.

The primitive iliac has been ligated for the cure of aneurism, chiefly of the external iliac, 31 times, with 22 deaths and 9 recoveries. The abdominal aorta has been tied seven times for aneurism of the common and external

* Norris's Contributions to Surgery, Philadelphia, 1874.

† American Journal of the Medical Sciences, New Series, July, 1864.

iliac arteries, and each time with a fatal result. The following table contains a brief summary of these remarkable operations.

Operation.	Sex.	Age.	Result.	Aneurism and Operation.
1. Sir Astley Cooper, 1817.	Male.	38.	Death in 40 hours.	The aneurism was connected with the iliac (left), but had become diffused in consequence of a rupture of the sac. The ligature was applied three-quarters of an inch above the point where the vessel divides into the primitive iliacs. The aorta was reached by an incision to the left of the umbilicus, opening the parietal peritoneum, pushing aside the coils of intestine, and reaching the artery by scratching an opening through the visceral layer of the peritoneum: a distal ligature had been previously applied to the external iliac in this case.
2. James, 1829.	Male.	44.	Death in 3 hours.	External iliac aneurism. The vessel had been tied on the distal side of the sac. The aorta was tied five lines below the inferior mesenteric artery, by opening the peritoneum in front.
3. Murray, 1834.	Male.	33.	Death in 23 hours.	External iliac aneurism of the right side; the limb was threatened with mortification in consequence of pressure on the pelvic blood-vessels by the great size of the sac. The aorta was approached from the left side, the incision being made from the anterior extremity of the tenth rib to the anterior superior spinous process of the ilium, the vessel being exposed behind the peritoneum; tied three lines above its bifurcation.
4. Monteiro, 1842.	Male.	31.	Death in 10 days.	False aneurism, caused by rupture of the upper part of the femoral, the blood diffusing itself through the pelvis and the thigh. Incision similar to that of Murray, and the aorta secured behind the peritoneum, four or five lines above its bifurcation.
5. South, 1856.	Male.	28.	Death in 43 hours.	Aneurism very large, involving both the external and the common iliac arteries. The vessel was tied above the peritoneum.
6. McGuire, 1868.	Male.	30.	Death in 11 hours.	Aneurism involved the left external iliac, and both primitive iliacs. The sac gave way during the operation. The ligature was applied to the aorta near to the inferior mesenteric.
7. W. Stokes, 1869.	Male.	50.	Death in 13 hours.	Iliac aneurism. The vessel was tied behind the peritoneum, though the latter was slightly wounded in the operation.

There are no difficulties which the hand of the surgeon will not brave when there is the faintest prospect of saving human life; but there is a point where the unalterable laws of structure are superior to the art of the operator, and where his hand must be stayed. This point, it is thought by some, has been reached in reference to ligation of the abdominal aorta for the cure of aneurisms; and yet I am unwilling to believe that seven failures constitute a sufficient argument for a dogmatic condemnation of this operation. Had such precedents been allowed to go unchallenged when applied to the surgical diseases which fall within the domain of gynæcology, a vast army of noble mothers would have been consigned, some to death, others to a seclusion even worse than death. No argument, in my judgment, short of the utter insufficiency of the collateral vessels to maintain the life of the inferior extremities, can be sufficiently cogent to exclude the ligation of the ventral aorta from the pale of operative surgery. I should, therefore, in the event of undertaking the ligature of the common iliac for aneurism and finding on exposure of the parts that the extent of the disease necessitated either tying the aorta or abandoning my patient to certain death, have no hesitation in accepting the former alternative.

Aneurism of the Femoral Artery.

Among aneurisms which are external in position, dilatation of the femoral artery comes next in frequency to that of the popliteal. Of the 551 cases of aneurism recorded in the tables of Crisp, 66 were of the femoral artery: of these 61 were males and 5 females. The disease is equally common on either side. Considered in connection with aneurism, there are only two surgical divisions of the femoral artery, namely, that portion of the vessel which corresponds to Scarpa's triangle, or from Poupart's ligament to the point where the adductor longus is crossed by the sartorius muscle, and that portion from the last-named muscle to the aponeurotic canal of the adductor magnus. Of 88 aneurisms of the femoral,* 55 occupied the first of the surgical divisions above named, and 33 the second. In 50 cases in which the limb is mentioned, 24 were on the right side and 26 on the left. The largest number of cases occurred in the decade between thirty and forty, and among the laboring population. Malgaigne's statistics include 68 cases of inguinal aneurism, and in 48 of these the disease was 25 times on the right side, 21 times on the left, and twice on both sides.

The term "femoro-popliteal aneurism" is in most instances a misnomer, if by it is meant that the disease begins in the femoral and extends to the popliteal artery. In my experience the reverse is the case, the aneurism commencing in the popliteal and gradually involving the femoral.

Symptoms.—The signs which indicate aneurism of the femoral artery do not materially differ from those which are present when the disease is situated in other vessels. There is a gradually-enlarging tumor imparting the characteristic pulsation to the hand, the movement being often visible to the eye, together with a distinct thrill and blowing sound heard on applying the ear over the surface of the swelling.

Diagnosis.—Most of the cases of aneurism in which errors of diagnosis have been committed have been connected with the femoral artery, and in every instance the aneurismal swelling was supposed to be an abscess. It is impossible that such a mistake can occur if a careful examination of the tumor be made. In all cases of aneurism, though the pulsation may sometimes be masked, the existence of a bellows murmur and a thrill can always be detected by the ear, either with or without the aid of the stethoscope. Further, it may be observed that pressure on the femoral or on the external iliac artery will not only arrest the pulsation and the sound, but will also sensibly diminish the size of an aneurismal swelling, whereas in abscess the size of the purulent collection will not be affected by interrupting the circulation. There is also in abscess, usually, a history of tenderness, redness, and induration, succeeded by central pointing and softening, symptoms which do not, as a rule, belong to aneurism. In a psoas abscess which finds its way to the thigh there is an absence of visible inflammatory phenomena, in which respect some resemblance may be said to exist between this disease and femoral aneurism; but the position of the former, being external to the blood-vessels, renders the distinction quite apparent.

Extension of the Disease.—When the aneurism is situated in the upper part of Scarpa's triangle it may gradually involve the external iliac artery by passing beneath Poupart's ligament into the pelvis, the resistance of the ligament causing a constriction of the sac and giving to the latter an hour-glass shape.

Treatment.—Femoral aneurism is treated by compression, by flexion, and by ligature.

Compression, in a large proportion of cases, if judiciously employed, will effect a cure. In three instances in succession I was able to bring to a favorable termination aneurism of the femoral at periods varying from twenty-four to forty-eight hours. Flexion by bending the thigh upon the abdomen has also succeeded in curing the disease.

* Hunter's manuscript collection.

Ligation.—In 88 cases of femoral aneurism* the external iliac was tied 39 times, with 31 successes. In 4 of these successes the cure was completed only after amputation in 2 cases in consequence of gangrene, and in 2 others after distal ligature and distal pressure in order to control hemorrhage. Of the 8 fatal cases, 1 died from secondary hemorrhage and 3 from gangrene; in 4 no cause was assigned. In the 66 cases of femoral aneurism tabulated by Crisp, and to which reference has been previously made, the external iliac was tied 43 times, and the latter vessel together with the femoral twice; 35 of these operations were successful and 10 unsuccessful. Of the latter, 3 died from hemorrhage, 2 from sloughing of the sac, 2 from gangrene, 1 from exhaustion, 1 from tetanus, and 1 without any known cause. In 33 cases the femoral was ligated 19 times, with the following result: 7 recovered, 9 died, in 2 the termination was not recorded, and in 1, though the patient recovered from the ligature, the pulsation returned in the sac. In the fatal cases the principal cause of death was secondary hemorrhage. With the surgeons of Dublin the results after ligating the femoral artery for femoral aneurism and for wounds have been singularly favorable, 11 recoveries and 2 deaths having followed 13 operations.† The same may be said of the 12 cases recorded by Crisp in which the femoral artery was tied, all of which, with three exceptions, recovered. It must be observed, however, that in the record of these ligations the portion of the vessel secured is not always stated. The experience of Mott was also highly favorable to this operation. Erichsen states that of 12 cases of ligature of the common femoral for aneurism but 3 were successful; secondary hemorrhage followed in 9, proving fatal in 3 instances, and in 6 being controlled only by ligature of the external iliac. The difference in point of fatality between the ligature of the external iliac and that of the femoral in this aneurism is very striking, and is to be referred to the uncertainty attending the safe detachment of a thread from the femoral when applied so near the origin of a large trunk like the profunda femoris.

When the aneurism is situated in the thigh, not higher than the apex of Scarpa's triangle, unless the vessel proves to be unsound the ligature should be applied between the sac and the profunda femoris; but when higher than this,—that is, nearer to Poupart's ligament,—or when the walls of the artery are in an atheromatous condition above the aneurism, the alternatives are left of tying the vessel above the profunda femoris, or of securing the external iliac; and since to decide this important question will require a more extended experience in these two operations than is at present possessed, while I give the preference to the latter operation, I am not prepared to condemn a further trial of the former.

Aneurism of the Profunda Femoris Artery.

Aneurism of the profunda femoris is exceedingly rare. In one case I have seen this vessel participate in the dilatation of the femoral. Erichsen mentions five cases, and Bryant one.

The symptom attending such an aneurism is the existence of a deeply-situated tumor, commencing about two inches below Poupart's ligament, or at the origin of the deep femoral, and extending down towards the middle of the thigh, having a strong pulsation, accompanied with a thrill and blowing sound. The beat of the superficial femoral can be discovered in front of the tumor, and its independence of the latter may be ascertained by raising the vessel between the thumb and fingers from the aneurism. In two instances I have seen large malignant growths develop in this region of the thigh which might from their great vascularity and their relation to the femoral artery have been readily mistaken for aneurism, in consequence of

* Hunter's manuscript collection.

† Dublin Quarterly Journal, 1869; also British Medical Journal, October, 1867.

the pulsation which permeated their structure; but in neither was there either thrill or bruit.

TREATMENT.—Aneurism of the profunda femoris is favorably situated for the treatment by compression, either digital or instrumental. The former is to be preferred, and should be applied to the common femoral immediately below Poupart's ligament, or to the external iliac above. In this way Erichsen succeeded in curing in twenty-four hours a case which came under his care at the University College Hospital. If pressure fails, a ligature should be applied to the femoral artery between the origin of the profunda and Poupart's ligament.

Aneurism of the Popliteal Artery.

Aneurisms of the popliteal constitute a very large proportion of all encountered by the surgeon, that artery being more frequently attacked by the disease than any other vessel of the body except the thoracic aorta. Of 84 cases of popliteal aneurism,* 41 were on the right side and 43 on the left side; and of 143 examples of the same disease, 123 were in males, 8 in females, and in 12 the sex was not stated. The largest number of cases (70) occurred between the ages of thirty and forty; though instances of the disease have been observed as early as the twentieth year of life, and in one case, mentioned by Syme, it occurred at seven years. Not unfrequently popliteal aneurism affects both vessels simultaneously. This was the case 11 times in 137 cases of the disease recorded by Crisp.

There are a number of circumstances which render this artery peculiarly liable to aneurismal dilatation. These are the slight degree of support which the vessel receives from the loose tissue that occupies the ham, the abrupt bends and severe stretching to which it is subjected in the movements of flexion and extension, and its alleged unusual liability to atheromatous degeneration.

Occupation is thought to exercise a determining influence in the production of this aneurism. According to Crisp, sailors and soldiers are most exposed to the disease. I do not think, however, that the records of Philadelphia hospitals will sustain this statement. The cases of popliteal aneurism which I have seen have been distributed about equally among tailors, miners, watchmen, and common laborers.

DIAGNOSIS.—Little difficulty is usually experienced in establishing the existence of popliteal aneurism. It is quite common for patients suffering from this affection to be able to specify the very moment at which the accident occurred. A sharp pain in the ham, or a feeling as if a severe blow had been received from an unseen missile, is the recognized manifestation which has often been mentioned when persons laboring under the disease have detailed to me the history of their cases. *Abscess, enlargement of the popliteal glands*, and *enlargement of the bursæ* which lie under the heads of the gastrocnemius muscle, are the diseases with which aneurism of this region has been confounded. In none of these, however, does either thrill or murmur exist; in none is the bulk of the swelling affected by pressure upon the femoral artery; and in none is the pulsation expansive, phenomena almost always associated with aneurism. The existence of inflammatory signs which belong to abscess, and which are exceptional in aneurism, will likewise aid in establishing the diagnosis between these two affections; and should any doubt, after such considerations, still linger in the mind of the surgeon, it may be resolved by the use of a very delicate exploring-needle, which will reveal, in case of abscess, some drops of pus; in the case of a bursa, a honey-like fluid; but which, if the tumor is aneurismal, will draw off a certain amount of blood.

TERMINATION.—Popliteal aneurism, when allowed to progress without interference, will cause marked weakness and pain in the leg, from pressure against the popliteal nerve, erosion of the femur, œdema from obstruction to

* Hunter's manuscript collection.

the flow of blood through the companion vein, mortification of the parts below the tumor, and not unfrequently to rupture, the sac discharging its contents into the cellular tissue of the ham, or even into the tibio-femoral articulation. In a few instances the disease has undergone a spontaneous cure.

TREATMENT.—*Compression.*—The success which has attended pressure in the treatment of popliteal aneurism renders it always desirable to give this method precedence over all others. In seven successive cases I have succeeded in effecting perfect cures by digital compression. The pressure should be made, in the manner already detailed in my general remarks upon the treatment of aneurism, over the femoral immediately below Poupart's ligament, where, from its superficial situation, the circulation through the vessel can be most easily arrested. Should the surface of the skin become tender, the pressure may be shifted to another point lower down, always observing to dust the surface compressed with finely prepared chalk. A sufficient number of assistants must be on hand to relieve one another, and, in order that the patient may be able to endure the treatment, morphia should be injected under the skin in such quantities and at such intervals as to prevent any severe pain or marked restlessness. Pressure is often applied by instrumental means, and may be advantageously assisted by flexion. The degree of success attending the method by compression may be approximately determined, when I state that out of 403 cases of popliteal aneurism treated by compression, which I have collected from various sources noticed below, 250 were cured.* The longest time required for the cure of any one of these aneurisms was forty-one and a half days, and the shortest period seventy-six minutes.

Ligation.—Until the time that the Hunterian operation was introduced for the cure of popliteal aneurism, ligation had proved so unsuccessful that amputation was regarded by some surgeons as offering the best prospect of a cure. When, however, the superiority of the proximal ligature was established, the plan of Hunter supplanted, until the introduction of compression, all other modes of treatment.

The femoral should be exposed at the apex of Scarpa's triangle, and tied with the animal thread, both ends of which must be cut off and the wound immediately closed. In 110 cases in which the Hunterian operation was performed for the cure of popliteal aneurism, 91 proved successful, and 7 others recovered after amputation of the limb, the ligature having been first used.† In 278 cases of ligation for the same disease, which I have gathered together from various sources, chiefly from the same collections as have been named under the head of compression, 173 were perfectly cured. The tables of Norris contain 153 cases of true popliteal aneurism for which the femoral artery was tied, 112 of which were cured. Four of the successful cases required amputation, in consequence of mortification following the use of the ligature. Of the 41 fatal terminations, 20, or one-half, were caused by gangrene. Morton, in recording the ligations done in the Pennsylvania Hospital for popliteal aneurism from 1835 to 1868, mentions 5 cases, all of which recovered.‡ It will be perceived that the tables of Norris, when studied with reference to the fatality attending ligation of the femoral for popliteal aneurism alone, yield a much more favorable percentage of cures than do statistics based upon ligation of the same vessel for aneurism other than popliteal and for hemorrhage from different causes.

Acupressure has been used in a few cases of the disease with success by Dr. Cheever, of Boston, Mr. Henry Lee, and others.

Occasionally it may be found necessary in popliteal aneurism, where the femoral artery is diseased, or in consequence of hemorrhage following the

* Prager Vierteljahresschrift, 1869; also Lancet, 1855, vol. i. p. 210; 1858, vol. i. p. 192; 1875, vol. i. p. 589; also Hunter's manuscript collection, 1877.

† Crisp's Diseases of the Blood-Vessels, p. 226.

‡ American Journal of the Medical Sciences, April, 1876.

separation of the ligature from this vessel, to tie the external iliac. A very remarkable case of this kind was recently under my care. The patient was a stout farmer, thirty-four years of age, apparently healthy, but had led a somewhat dissipated life. Four years previous he had, after lifting a heavy weight, felt something give way, shortly after which a tumor appeared in the ham. The pain and large size of the swelling induced him to seek surgical relief. Pressure, after some days of preliminary treatment, was tried, without success, and following this the Esmarch bandage was applied for one hour, with no better result. After allowing the patient a few days' repose, I ligated the femoral artery, with the catgut thread, at the point where the vessel is crossed by the sartorius muscle. All pulsation immediately ceased in the tumor. Nine days after, secondary hemorrhage occurred. The wound was opened, and the bleeding found to proceed from a perforating ulcer in the femoral above the ligature. No coagulum whatever existed in the vessel. The artery was tied above and below the opening, and the wound again closed. Eight days after the second ligation another hemorrhage took place, when the wound was again opened, and an ulceration discovered in the profunda femoris. The vessel was tied above and below the lesion, and the wound closed a second time. Everything progressed favorably for eleven days, when the bleeding was renewed, at which time the femoral, in my absence, was tied by Dr. Hunter. For fourteen days following this operation the patient did well. On the evening of the fourteenth day the hemorrhage was renewed, but was promptly controlled by pressure. Indeed, at no time was any large amount of blood lost, as the man was carefully watched by the nurse and assistants day and night. I now proceeded to ligate the external iliac artery, and during the operation noticed that the blood remained fluid in the vessel down to the point of the last ligature on the femoral. The day following the deligation of the external iliac, a profuse flow of blood took place from the wound on the thigh, which I found proceeded from the obturator artery. This bleeding vessel was secured, and nothing of importance occurred for five days, when an unusually violent hemorrhage ensued, in the night, from the thigh, and, as it was found impossible to arrest it, the common iliac was tied by Dr. Hunter. Though the patient in this last attack lost a considerable amount of blood, he promptly rallied, and had no return of the bleeding until the lapse of seven days, when a sudden flow was seen issuing from the opening in the abdominal walls. An abdominal tourniquet, which had been previously provided, was quickly screwed down; but too late. The patient expired in a few minutes after the hemorrhage was discovered. The post-mortem revealed the existence of an ulcer, which had opened the common iliac above the ligature, and through which the blood had escaped.

Cases of double popliteal aneurism should be first treated singly by compression; but if this plan fails, and it becomes necessary to resort to the ligature, the two femorals should not be tied simultaneously, but consecutively. In a case of double popliteal aneurism which was under my care in 1867, I effected an entire cure by digital compression.

Mortification of the limb.—When, after the ligation of the femoral, mortification ensues, and shows an unmistakable tendency to extend, amputation is the only resource, and one which offers the patient a very fair chance of recovery.

Aneurism of the Tibial Arteries.

Aneurism of the tibial arteries is exceedingly rare. Two examples of the disease, affecting the posterior tibial, are contained in the tables of Crisp, and one of the same artery is in the collection of Norris. In 1875 I saw a case of spontaneous aneurism of the anterior and posterior tibial arteries, in consultation with Dr. De F. Willard, of this city. The patient was a man sixty-five years of age, and attributed the presence of the tumor to a long walk. At each cardiac systole the head of the fibula was driven

violently outward, and the whole calf pulsated visibly. The aneurism was cured in thirty-two hours, by digital compression.* Traumatic aneurism is more common than the spontaneous, and may be produced by gunshot or punctured wounds of the leg.

TREATMENT.—In the spontaneous form of the disease, pressure of the femoral, as in popliteal aneurism, should be first tested, and, if unsuccessful, it will be proper to expose the vessel and apply a ligature on both the proximal and the distal side of the sac. In the traumatic variety, after the failure of compression, the femoral artery must be compressed by a tourniquet, after which the swelling should be thoroughly exposed, the extravasated blood removed, and the torn vessel tied above and below the lesion.

* Philadelphia Medical Times, September 25, 1875.

CHAPTER VIII.

LIGATION OF ARTERIES.

General Observations.—No operation upon the human body demands greater skill or more exact anatomical knowledge than does the ligation of the great arterial blood-vessels. The most elaborate diagrammatic illustrations, together with the minutest detail of every step necessary for the execution of such a work, can never take the place of the dissecting- and the operating-room. These constitute the gymnasium where the student must train before he presumes to attempt operations of so delicate a nature as those which constitute the subject of the present chapter. The surgeon, before undertaking to expose and ligate one of the principal arteries of the body, should possess an accurate knowledge of the surface or artistic anatomy of the region to be traversed, which includes all the depressions, elevations, lines, and prominences that belong to its external configuration. He should be acquainted not only with all the anatomical components of the surgical regions, but also with their exact order and the relations which they sustain to one another. All abnormal distribution of vessels should also be understood. In fine, his knowledge of special and topographical anatomy should be so thorough that at any moment he can reproduce a mental picture of each particular region before a single incision has been made.

Instruments.—The instruments required for the ligation of arteries are one or two scalpels, two forceps, one grooved director, an eyed probe, retractors, a tenaculum, three or four forms of the aneurismal needle, catgut or silk ligatures, and a tourniquet. These instruments are represented in the cuts on the opposite page (Figs. 403 to 411). For dressing the wound after the operation, there will be required a needle, silver wire, adhesive plaster, compresses, and rollers.

As the mariner drives his ship towards some desired haven, and nears the point of his destination, every indentation and salient point of the coast-line is scanned with interest; but it is only the signals which stream from the towering light-house or the floating buoys which command his explicit faith. So it is with the surgeon who carries his operation into regions of the body surrounded on every side with important life-organs: every structure has to him a significance, but there are one or two points distinguished from all others, towards which he invariably and instinctively turns for light in every moment of perplexity or of doubt. These referential points are generally some prominence of the skeleton, or the border of some tendon or muscle, selected, above all others, in consequence of invariability and fixedness of position.

Prerequisites for the ligation of arteries.—The following rules may be presented for the guidance of the operator in the ligation of vessels:

1. *There must be a distinct recognition of the position and course of the artery to be tied.*

To one very familiar with his art this knowledge becomes an intuition. The eye glances over the surface, and a line is drawn mentally in the direction of the vessel. To those, however, who are less familiar with the subject, it may be necessary to draw real lines between well-known points which, from experience, have been found to indicate the course of the artery. The muscular swells and the intermediate depressions also convey important information, as the arteries occupy the intermuscular spaces, or follow a direction corre-

sponding to the borders of certain muscles. In order to render the latter prominent, it will sometimes be necessary to vary the position of a part. To

FIG. 403.

Scalpel.

FIG. 404.

Forceps.

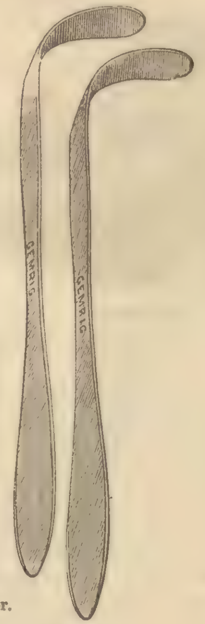
FIG. 405.

Tenaculum.

FIG. 406.

Grooved director.

FIG. 407.



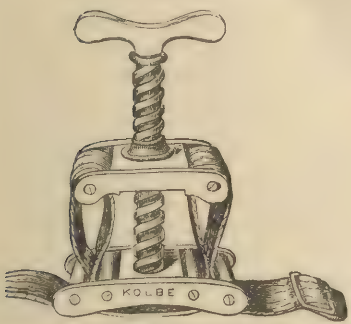
Retractor.

FIG. 408.

Eyed probe.

make either the border of a muscle or the extension of lines truly valuable, the part observed or measured must be placed in the proper position, and not

FIG 409.



Tourniquet.

FIG. 410.

Cooper's aneurismal needle.

FIG. 411.

Parrish's aneurismal needle, consisting of a handle and a stem, with a number of needles of different curves. These have an eye near each extremity, and can be screwed to or detached from the stem of the instrument at pleasure.

afterwards changed during the operation. Neglect of these points may lead the operator wide of his mark.

Another valuable means by which to localize an artery is the use of pressure, with a view to detect its pulsation. This pressure should be as direct as possible, should be made with the fingers of one or both hands (Fig. 412), and with no more force than is absolutely necessary to acquire the information, as when pressure is made obliquely to the surface or with undue power the

vessel may be so far thrust out of its normal situation that, when the fingers are removed, the correspondence between the surface of the skin pressed and the artery is materially changed from that which existed where the pulsation was felt.

Fig. 412.

The fingers searching for the vascular groove, and feeling for the pulsation of the artery; the thigh used as an illustration.

2. *The exposure of the artery.*—The order of the superposition of tissues in the body is as follows: first, the skin or integument; second, the superficial fascia, which consists of connective and adipose tissue; third, the deep fascia; and, fourth, the muscular structures and the intermuscular connective tissue. The first three strata should be divided separately, the second and third layers always being raised upon the director before being incised. A difference of opinion exists in regard to the direction in which the incision of the tegumentary and other planes of tissues should be made; some advocating their division parallel with, and others obliquely to, the course of the vessel to be exposed, the middle of the wound answering to the part of the artery to be ligated. As a rule, I much prefer an incision parallel with the direction of the vessel, as the subsequent apposition of the sides of the wound is more easily effected than when it is made oblique. When, however, the operator has some distrust as to the accuracy of his anatomical knowledge, it is better to adopt the latter plan in regard to the skin and superficial fascia, as by so doing he will be more likely to reach the vessel. To prevent the skin from sliding when being divided by the knife, it should be fixed by the thumb and finger of the other hand. (Fig. 413.) The skin, and the superficial and deep fasciæ, should be incised to an equal extent. Any vessel which may bleed persistently during the preliminary incisions must be tied, so that there shall be no blood to embarrass the future steps of the operation.

Fig. 413.

The skin fixed by the fingers of the left hand while the first incision is being made.

Another very important point is to ascertain the intermuscular fissure which leads down to the artery. This can generally be recognized before opening the deep fascia, if the latter be properly cleaned. The fissure will appear as a slightly yellow or fatty line. Another guide, which I have found of great value, is the presence of small vessels which, coming up from the artery in question, perforate the deep fascia immediately over the intermuscular fissure to be opened.

The line being determined, the deep fascia should be raised on the director and divided. This accomplished, the cutting edge of the knife is no longer to be used. The intermuscular space must be opened by running the director, the handle of the scalpel, or the finger upwards and downwards, and breaking up the loose cellular tissue until the sheath of the vessels is reached. In order to identify the latter, the pulsation of the artery can generally be

felt; if not, it will become necessary to refer to other anatomical parts, as nerves, veins, or prominences belonging to the skeleton, which are known to have a definite relation to the vessels.

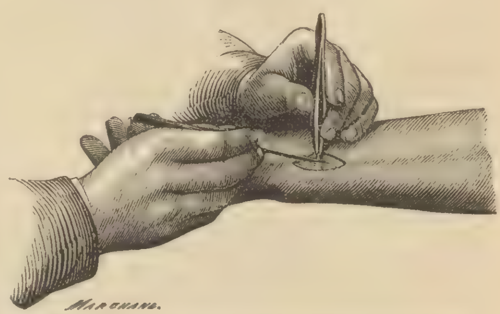
3. *Opening the sheath.*—That this may be done with entire safety, the intermuscular space should be widened, by introducing on each side a retractor and drawing its sides apart. (Fig. 414.) If the wound is deep, it may be necessary to notch the fascia on each side, in order to admit of its free retraction. The sheath being exposed, a little fold of the membrane should be picked up with the forceps and divided, with the knife held in such a manner that the cutting edge will be directed away from the vessel. (Figs. 414 and 415.) The little opening made by the bistoury should be next enlarged, by introducing the point of the director and moving it upwards and downwards on both sides of the artery until the latter is completely isolated from its companion vein or veins. In accomplishing this part of the operation, no more disturbance of the sheath is allowable than will answer for the passage of the ligature. This is not an unimportant requirement. If it is disregarded, and the membrane extensively lacerated, the nutrition of the vessel will be disturbed, which may interfere with the safe detachment of the ligature from its walls or cause a diffused perivascular abscess.

Fig. 414.

Retractors holding the sides of the incision widely apart, while the sheath of the vessels is being opened.

4. *The recognition and deligation of the artery.*—Though the artery can generally be recognized by its pulsation, yet sometimes this may not be present, or may be so faint as to create a doubt in regard to the identity of the vessel, and then the surgeon must satisfy his mind by other tests. Arteries have frequently been confounded with tendons, veins, and nerves. Tendons, from being almost pearly white and of a dense consistence, are in striking contrast with arteries, which have a buff color and are compressible. The thin walls of veins and the deep blue color of the blood, visible through their coats, are sufficient to distinguish them from arteries, the walls of which are thick and opaque. The closest resemblance exists between an artery and a nerve. The latter, however, rolled between the thumb and finger, imparts only the sensation of a solid cord, while the former, treated in the same manner, is flattened, and conveys the feeling of two surfaces sliding on each other. In a patient not under the effect of an anæsthetic it would, of course, be easy to discriminate between the two, from the painful sensations awakened by pinching the nerve. The recognition and isolation of the artery being completed, it should be raised on the director, along the groove of which may be next passed a probe bearing a ligature. The thread being disengaged, both

Fig. 415.



Raising a fold of the sheath and dividing it with a knife.

director and probe should be withdrawn, and the trunk raised and compressed between the thumb and fingers before tying the thread, in order to ascertain that the pulsation is arrested below, and that no other structure is included with the vessel in the ligature. In some instances it will be found more convenient to pass the ligature by means of some one of the different needles already described, at the same time favoring the passage by making counter-pressure with the finger against the point of the instrument. Whatever instrument is used for this purpose, the point should be blunt, and it should always be introduced between the artery and the vein, so that the latter shall not be wounded.

Ligation of the Innominate Artery.

Surgical anatomy.—The innominate artery is the largest branch given off from the arch of the aorta. In length it varies from an inch and a half to an inch and five-eighths. Rising from the commencement of the transverse portion of the arch of the aorta, it inclines gently to the right side, and at the sterno-clavicular articulation divides into the right carotid and subclavian arteries. By extending the neck, the innominate can be drawn up and rendered more superficial.

Enumerating the parts from the surface inwards, in front of the vessel lie the skin, superficial fascia, deep fascia, sternum, the great transverse and inferior thyroid veins, the remains of the thymus gland, the sterno-hyoid and sterno-thyroid muscles; behind, the artery rests upon the trachea; on its left side are the left carotid and a remnant of the thymus gland; and on the right side are the right innominate vein, the right pneumogastric nerve, and the inner surface of the summit of the pleura. The artery is occasionally the subject of an irregularity, both in its division and in its course. The bifurcation may take place above or below the sterno-clavicular articulation; the first is most common: either of these departures from the normal point will necessarily affect its length, it being longer in the first and shorter in the second case. In one instance in a subject whose neck I was dissecting, I observed the innominate to ascend perpendicularly out of the chest and pass up directly in front of the trachea, almost to the cricoid cartilage, before turning to the right side. The brachio-cephalic branches in this case were given off just as the vessel left the trachea. There are cases in which the innominate gives off both the right and the left carotid and the right subclavian arteries, and in rare instances the vessel has been absent.

Ligation.—There are two incisions for the ligation of the innominate,—the L-shaped and the linear. The first was the one employed by Dr. Mott, and the second has been recommended by King and by Manec, neither of whom, however, ever tied the vessel. By the last method the parts are divided along the anterior edge of the sterno-cleido-mastoid muscle. It is simply an impracticable procedure, and need not be described.

Method of Mott.—The patient is placed on his back, with the head well thrown back and a little inclined to the left side. The surgeon, stationed on the right side, makes a horizontal incision two inches and a half long through the skin, superficial fascia, and platysma myoides muscle, commencing at the median line of the neck, half an inch above and parallel with the top of the sternum and the clavicle. A second incision of the same length is carried down along the anterior margin of the sterno-mastoid muscle until it joins the first at the top of the sternum. The sternal and most of the clavicular origin of the sterno-cleido-mastoid muscle is next separated by a director from the underlying fascia, is divided by an incision in the direction of the one first made, using the finger passed beneath the muscle as a guide, and is turned out of the way. Pressing aside the thyroid veins, the sterno-hyoid and thyroid muscles are now to be carefully raised on the director and cut across. A little scratching with the director will reveal the sheath of the right carotid, which should be opened and the artery traced down until the

innominate is reached. At this stage commences the most difficult and dangerous part of the task, namely, the safe isolation of the artery and its deligation. In using the director for the purpose of denuding the vessel, the utmost care must be observed to avoid the right and left innominate veins, and, in passing the ligature, not to injure the pleura.

History of ligation of the innominate.—The idea of ligating the innominate artery was first conceived by Allan Burns. This anatomist was satisfied that the collateral vessels, even in the absence of so large and important a channel as the brachio-cephalic, would be sufficient to supply the head, neck, and upper extremities with blood.

The innominate artery was first tied by Dr. Valentine Mott, of New York, in 1818, for subclavian aneurism, in a male patient fifty-seven years old. The ligature separated on the fourteenth day. Two attacks of secondary hemorrhage followed, the one on the ninth and the other on the twenty-third day, from the effects of which the patient died on the twenty-sixth day. The ligature was found to have cut its way through the vessel by ulceration, but no clot had formed to close up its canal.

The second operation was performed by Graefe, in 1822, on a man likewise suffering from subclavian aneurism. The ligature separated on the fourteenth day, and the patient survived sixty-seven days, perishing finally from hemorrhage.

The third ligation was made by Norman, in 1824, for subclavian aneurism: he lost his patient in sixty hours, from acute pericarditis.

The fourth operation was done by Arendt, also in 1824, and proved fatal on the eighth day, from a rapid inflammation of the sac and pleuro-pneumonia.

The fifth operation was performed by Hall, in 1830. It was attended with great difficulty, in consequence of the diseased condition of the vessel, which was wounded during the act of denudation, and for which the wound had to be tamponed. The patient died on the fifth day.

The sixth operation was done by Bland, in a man thirty-one years of age. The patient died on the eighteenth day, from the effects of a hemorrhage occurring the day previous. In this case the carotid and the innominate were closed by coagula, but the subclavian remained pervious.

The seventh operation was executed in 1837, by Lizars. The ligature separated on the seventeenth day, and on the twenty-first day death occurred from hemorrhage.

The eighth operation was done by Hutin, in 1842. In this case there had been a previous wound of the axillary artery, for which the subclavian artery had been tied; this had been followed by severe bleeding, to arrest which the innominate was ligated. The patient died in twelve hours after the deligation.

The ninth operation was performed by Cooper, of San Francisco, in 1859, for aneurism of the subclavian and carotid arteries. The patient died on the ninth day, in consequence of blood-poisoning from disease of one of the kidneys.

The tenth operation was also done by Cooper, in 1860, for subclavian aneurism. The ligature separated on the eighteenth day. Twenty-one days following, hemorrhage occurred, and on the forty-first day the patient died. In both the operations of Cooper a portion of the sternum and clavicle, answering to the sterno-clavicular articulation, was removed to admit of an easy access to the vessel.

The eleventh operation, by Gore, was performed for axillary and subclavian aneurism. Death occurred on the seventeenth day, from hemorrhage.

The twelfth operation, the most remarkable on record, was done by Smyth, of New Orleans. This surgeon, in consequence of a subclavian aneurism having a traumatic origin, tied simultaneously the innominate and the carotid arteries, the former a quarter of an inch below its division, the latter one inch above its origin. On the fourteenth day secondary hemor-

rhage took place, which was arrested by filling the wound with shot. Two other attacks of bleeding occurred on the thirty-third and fifty-first days, which were controlled in the same way as in the first instance. On the fifty-fourth day the hemorrhage was renewed, and at this time the vertebral artery was tied. After this the brachial artery became closed. In a few days, however, the circulation was restored in the arm, and the patient recovered.

The other cases of ligation of the innominate artery, attributed to Dupuytren, Lynch, Pirogoff, Bugalsky, and Peixotto, cannot be said to rest on evidence sufficient to entitle them to unqualified acceptance. If such operations were really performed, they all, according to the testimony of those who refer to them, proved fatal.

Four times the operation has been abandoned after the exposure of the vessel, in consequence of extensive disease in the coats of the artery and from other structural alterations, which rendered the ligation impracticable. These were the cases of Porter, Post, Hoffman, and Ashton Key.

There are, therefore, twelve well-authenticated cases of deligation of the innominate artery, all, with a single exception, performed for aneurism, and all save one followed by a fatal result; or, if the five doubtful cases be admitted, there have been seventeen ligations of this vessel, with one recovery. The cause of death in every instance, with the exception of three, those of Norman and Arendt, and one of Cooper's, was hemorrhage; and it is more than probable that had these patients escaped the accidents from which they died, they would eventually have perished in the same manner as the others. In none of the cases, save that of Gore, was there even an approximation to a cure of the aneurism, and in this, though the sac was filled with coagulum, the tendency to hemorrhage was not lessened. Taking into account the close proximity of the innominate artery to the heart, the shortness of its trunk, the force of the circulation to which it is subjected, the evil effects of disturbing the cellular connections which link together so many important structures at the cervico-thoracic line, and the uniform fatality attending this ligation, I have no hesitation in saying that its claim to be accepted as a surgical procedure falls far short of that for the ligation of the abdominal aorta, and that it should meet with the unqualified condemnation of the profession.

Ligation of the Common Carotid Artery.

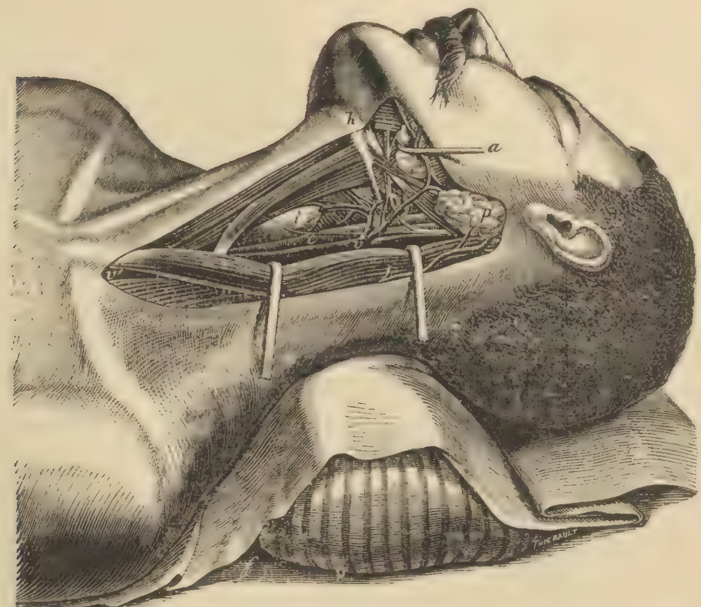
Surgical anatomy.—In consequence of the right primitive carotid artery having its origin from the innominate, and the left from the arch of the aorta, it follows that in their thoracic portions the surgical relations of the two vessels are not identical. The artery on the right side is shorter than the one on the left. The left vessel passes obliquely from its origin, into the neck, in front of the trachea, œsophagus, and the thoracic duct, with the remains of the thymus body, the left innominate vein, sterno-thyroid and sterno-hyoid muscles in front; on the right of the vessel lies the brachiocephalic artery, and on the left are the left subclavian artery and pneumogastric nerve. After the carotid arteries enter the neck their relations on the two sides are identical: the description of one will therefore answer for both. Commencing at the sterno-clavicular articulation, the carotid passes upwards and backwards, resting on the transverse processes of the cervical vertebræ, and in the direction of a line drawn from this point to the space midway between the angle of the jaw and the mastoid process of the temporal bone. The vessel becomes more superficial as it ascends the neck. The artery divides into its two branches, the external and internal carotids, usually opposite the hyoid bone. This division may take place a little above or below this point. In rare instances the vessel has been known to divide shortly after its origin, and occasionally the vessels have been seen to arise from a common trunk. In front are the skin, superficial fascia, platysma myoides, deep fascia, sterno-cleido-mastoid, sterno-hyoid, sterno-thyroid, and

omo-hyoid muscles, descendens noni nerve, and anterior jugular, lingual, facial, and thyroid veins. Behind are placed the longus colli and rectus anticus major muscles, the sympathetic and recurrent laryngeal nerves, and the inferior thyroid artery. Internally are situated the trachea, œsophagus, larynx, pharynx, recurrent laryngeal nerve, and some branches of the inferior thyroid artery; and externally lie the internal jugular vein and the pneumogastric nerve, in the sheath with the artery.

The vessel is crossed by the omo-hyoid muscle, and thereby divided into two surgical regions. The lower one, bounded by the sterno-cleido-mastoid, sterno-hyoid, and omo-hyoid muscles, is the anterior inferior cervical triangle of the topographical anatomist; and the upper one, bounded by the sterno-cleido, the omo-hyoid, and the base of the jaw, constitutes the anterior superior cervical triangle.

As the omo-hyoid muscle crosses the sheath of the vessels about its middle, this part becomes important in a surgical point of view, and will be found to correspond accurately to a line drawn directly across the neck from the cricoid cartilage outwards. (Fig. 416.) When the surgeon is at liberty to

FIG. 416.



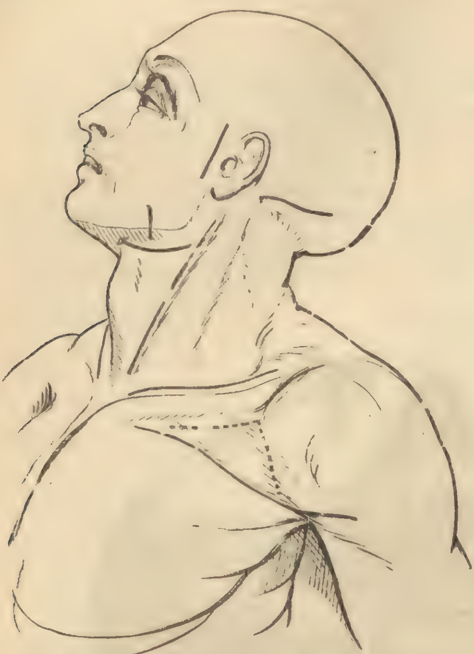
The carotid and its branches exposed. The sterno-cleido-mastoid muscle and the external jugular are drawn outwards by retractors. *v*, the internal jugular and its tributaries; *c*, the primitive carotid; *h*, the hyoid bone. The descendens noni rests in front of the vessels, though external to their sheath. Between the artery and the vein runs the pneumogastric nerve. The omo-hyoid is seen passing beneath the sterno-mastoid.

elect his operation, the vessel should be tied at the upper border of the omo-hyoid muscle.

Operation below the omo-hyoid muscle.—The patient should be placed in the recumbent position, the shoulder raised and thrown back, the head supported on a pillow and turned somewhat to the opposite side. An incision should now be made two and a half or three inches in length along the inner border of the sterno-cleido-mastoid muscle, terminating at the top of the sternum. (Fig. 417.) The skin, superficial fascia, and the platysma being divided, the deep fascia comes into view. Making a small opening into this membrane for the entrance of a director, it should be slit up to the full extent of the external incision, at the same time taking care that the anterior jugular, if present,

be not injured. At this stage of the operation a retractor should be inserted on each side of the wound and the parts drawn asunder. This done, another layer of the deep cervical fascia will be exposed, passing between the sterno-hyoid and sterno-thyroid muscles posteriorly and the sterno-mastoid anteriorly. This will require to be raised and opened, that the director may be introduced, after which it should be carefully divided,—not torn, as is sometimes done, an injury well calculated to favor a deep, diffused suppuration which may travel into the mediastinum or into other parts of the chest. If now the sterno-hyoid and sterno-thyroid muscles be drawn inward towards the trachea, and the sterno-mastoid outward,—which can be accomplished most easily by bringing the head a little forward,—the sheath of the carotid will be brought into view, lying in front of which will probably be seen the descendens noni nerve. A little fold of the sheath should now be picked up with the forceps and divided, in doing which the edge of the knife should be directed forward. With the point of the director introduced through this opening the isolation of the artery is commenced, during which the internal jugular vein, occupying the outer side of the sheath, will be seen alternately swelling and subsiding as the chest is contracted and dilated during the acts of expiration and inspiration. Cautiously separating the artery, on the inside from the pneumogastric nerve, and on the outside from the vein, the thread is next conducted around the vessel from without inward, so as to avoid injury to either nerve or vein. In passing the needle beneath the artery, it must not be forgotten that the sympathetic nerve is situated posteriorly, and, though external to the sheath, might be injured if this part of the operation were done in a careless manner.

Fig. 417.



Lines of incision for the ligation of the different arteries of the neck, face, and first part of the axillary.

In cases where from any cause difficulty is experienced in exposing the artery in this region, the sternal part of the sterno-mastoid muscle may be cut across, and, if necessary, the sterno-hyoid and sterno-thyroid muscles may be treated in a similar manner. In one instance Mr. Key was obliged to divide the first-named muscle before he could secure the artery; and Mr. Porter, of Dublin, in another case, was able to tie the vessel close to its origin by dividing all of these muscles.

Ligation of the common carotid above the omo-hyoid muscle.—This operation is not only much easier of execution from the superficial position of the vessel, but is always to be preferred for the application of a ligature, unless some peculiarity in the case prevent.

Operation.—The patient should be placed in the same position as when the vessel is tied below. An incision commencing one inch below the angle of the jaw should be carried down along the anterior border of the sterno-mastoid muscle, terminating half an inch below the cricoid cartilage. The superficial fascia, the platysma myoides, and the deep fascia are next to be divided consecutively on the director and to the extent of the cutaneous

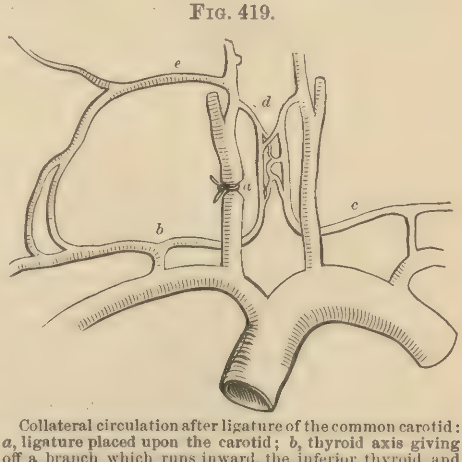
incision. Turning the edge of the sterno-mastoid muscle outward and bringing the head slightly forward, the intermuscular layer of the deep fascia can be next raised and divided, when the sheath of the vessels will be exposed, with perhaps the descendens noni nerve, and probably the communicans noni likewise. A small duplicature of the sheath being now raised with the forceps and cautiously opened, the director is to be inserted and the artery carefully separated from the companion nerve and vein, after which the needle, introduced between the artery and the pneumogastric nerve and the internal jugular, should be passed from without inward, carrying with it the ligature with which the vessel is to be tied. (Fig. 418.) The ligation of the primitive carotid may be required for the cure of aneurism and of erectile growths, and also in consequence of lesions of the vessel itself, caused either accidentally or in the removal of tumors, in which case the thread should be applied on both sides of the wound. Tying the carotid on account of wounds of its branches cannot be regarded as a wise surgical procedure. Recurrent hemorrhage will be likely to follow. It may be laid down as a rule that in wounds of the arteries of the neck the only safe practice is to tie the injured vessel, not the trunk from which it arises, and always with a double ligature, one on each side of the lesion.

Fig. 418.

The sides of the wound held asunder by retractors, and the common carotid raised on the needle passed from without inwards, in order to avoid the pneumogastric nerve and the internal jugular vein.

Collateral circulation.—When the blood-flow through the primitive carotid is interrupted by a ligature, the circulation is restored to the upper part of the neck and to the head by inosculation between the inferior thyroid arteries from the thyroid axis and the superior thyroid arteries of the external carotids, and also between the ascending branches of the transversalis colli from the thyroid axis and the princeps cervicis from the occipital. (Fig. 419.) There is also a free communication between the internal and the external carotid both on the outside of and within the skull. It is these numerous inosculations which explain the recurrence of hemorrhage even after the ligature of the common carotid; and to meet this difficulty, at least so far as the communication between the two carotids is concerned, it has been suggested, and in one case successfully

Fig. 419.



Collateral circulation after ligature of the common carotid: *a*, ligature placed upon the carotid; *b*, thyroid axis giving off a branch which runs inward, the inferior thyroid, and one which passes outward, the transversalis colli,—the first inosculating with the superior thyroid at *d*, from the external carotid of the same side, and the second communicating by its ascending branch with the princeps cervicis or descending branch of the occipital at *e*, also from the external carotid.

executed, by Dr. Gurdon Buck, of New York, to tie at the same time the common and the internal carotid vessels.

The mortality following the ligation of the carotid has been very great, both in civil and in military surgery. Dr. Norris has tabulated 149 cases of ligation of the primitive carotid.* Of this number, 94 recovered, 54 died, and in 1 the result was not determined. These ligations were classified, and I arrange them in a tabular form, as follows:

Disease.	Cured.	Recovered.	Died.	Unknown.
Aneurism	38	22	16	
Wounds	30	15	15	
Extirpation of tumors before and at the time of operation	18	12	6	
Cerebral affections	6	6	0	
Erectile tumors or arterial varices of the head or face	31	23	8	
Cure or arrest of growth of other tumors	11	6	5	
Brasdor's operation for aneurism	15	10	4	1
Total	149	94	54	1

Dr. Pilz, of Breslau,† has collected 586 well-authenticated and 14 partially corroborated ligations of the common carotid, in all making 600, of which number 319 recovered, 259 died, and 22 were without known result. This would show 43 deaths in every 100 cases of ligation. Dr. Pilz has followed the classification of Norris in arranging the affections for which the vessel was tied, as follows:

Disease.	Cases.	Cured.	Died.	Unknown.
Hemorrhage	228	94	128	6
Aneurism	87	55	31	1
Tumors	142	87	49	6
Extirpation	71	38	25	8
Affections of the nervous system	34	33	1	
Brasdor's method for aneurism	38	12	25	1
Total	600	319	259	22

An analysis of both Norris's and Pilz's tables shows that the danger of carotid ligations does not depend so much on the size or location of the vessel as on the character of the disease for which the operation is done. Thus, out of 40 ligations for the cure of cerebral disease (such as epilepsy, etc.), included in the two tables, all recovered from the operation save 1, while of 125 in which the artery was tied for aneurism, 47 died. In a list of 30 cases, tabulated by Dr. Morton, in which the common carotid was ligated for the cure of intraorbital aneurism, 27 recovered and 3 died,‡—another illustration of the comparative harmlessness of the operation in instances where the disease does not affect the soundness of the vessel.

Between the years 1836 and 1876 the primitive carotid was ligated in the Pennsylvania Hospital nine times, with 6 deaths and 3 recoveries.§

In military practice the mortality attending this operation reaches its maximum. During the War of the Rebellion there were 116 ligations of the common carotid for wounds of the face and the neck, 81 of which died.|| In every instance in which the vessel was tied for a shot- or sabre-wound of the

* Contributions to Practical Surgery.

† Langenbeck's Archives, 1868, vol. ix., pp. 257–445.

‡ American Journal of the Medical Sciences, April, 1865.

§ Ibid., April, 1876.

|| Surgical History of the War, Part I., surg. vol.

neck the patient perished. The great fatality attending deligation after such injuries, however, must be referred to causes which in themselves are necessarily fatal independent of the operation.

The organ which seems to suffer most after ligature of the common carotid is the brain, and accordingly we find that cerebral affections stand first among the causes of the mortality following this operation.

In the cases analyzed by Norris, 31 patients perished from brain disease, and in those of Pilz the mortality from this cause was in about the same proportion. The relative frequency with which cerebral symptoms arise after deligation of the primitive carotid for the cure of the various diseases enumerated is approximately as follows: after aneurism, once in every three cases; after wounds, once in every four cases; before and during the extirpation of tumors, once in every nine cases; for cerebral disease, once in thirty-four cases; after Brasdor's method, once in every seven cases; and for erectile tumors, once in every five cases. The greatest immunity—almost complete, indeed—appears to have been where the ligation was done for the cure or relief of certain nervous affections, such as epilepsy, neuralgia, etc. Hemorrhage comes next in order to cerebral disease as a cause of death after the ligation of this artery.

The following cases, collected from various medical journals by Dr. Hunter, and which I have arranged in the following table, embrace most of the ligations of the common carotid on record since 1867:

No.	Operator and Date.	Side.	Sex.	Age.	Disease.	Recoveries.	Deaths.	References and Remarks.
1	A. Hewson, 1867.	Right.	Male.	51	Innominate aneurism	......	1	Pennsylvania Hospital Reports, vol. ii.
2	W. Hunt, 1868.	"	Female.	28	Hemorrhage.	1	......	Am. Jour. Med. Sci., April, 1876.
3	T. Morton, 1869.	Left.	Male.	27	Hemorrhage.	......	1	Am. Jour. Med. Sci., April, 1876.
4	Mr. Jas. Lane, June 28, 1871.	Right.	Male.	39	Aneurism.	1	......	Lancet, October 14, 1871.
5	Mr. Gambee, April 15, 1871.	Left.	"	......	Aneurism.	......	1	Lancet, June 3, 1871.
6	Mr. Jas. Lane.	Right.	Female.	40	Aneurism at the root of the neck.	1	......	Lancet, Jan. 13, 1872. Subclavian and carotid both tied.
7	Mr. Heath, for Dr. Cockle, Feb. 26, 1872.	Left.	Male.	48	Aneurism of aorta.	1	......	Lancet, April 20, 1872.
8	Mr. Z. Lawrence, Feb. 19, 1867.	"	"	41	Aneurism, intraorbital	1	......	British Medical Journal, October 5, 1867.
9	Dr. Christ. Fleming.	"	"	40	Aneurism.	1	......	Dublin Jour. Med. Sci., August, 1873.
10	Mr. Bowker.	....	"	y'th	Traumatic aneurism of the internal maxillary artery.	1	......	Lancet, October 11, 1873.
11	Dr. H. B. Sands.	....	....	......	Secondary hemorrhage after removal of inferior maxillary.	1	......	New York Medical Journal, Jan. 1874.
12	Mr. Hulke.	"	"	31	Secondary hemorrhage after removal of cervical tumor.	......	1	Medical Times and Gazette, November 29, 1873.
13	Dr. R. W. Gebber.	"	"	40	Traumatic aneurism.	1	......	Charleston Medical Journal and Review, January, 1874. Wire ligature used.
14	Dr. Robt. Reyburn.	Right.	"	25	Aneurism.	1	......	Am. Jour. Med. Sci., 1868, lvi. 112.
15	Dr. H. B. Sands.	"	....	......	Aneurism of innominate.	1	......	Medical Record, 1869, vol. iii. p. 531. Carotid and subclavian tied.
16	Dr. H. E. Foote.	"	"	20	Orbital aneurism.	1	......	New York Medical Record, 1868, vol. iii. p. 75. Both carotids tied. Interval one year.
17	Joseph Bell.	Left.	"	42	Orbital aneurism.	1	......	Edinburgh Medical Journal, 1867, p. 36.
18	Dr. Stephen Smith.	"	....	......	Cancer of inferior maxillary.	1	......	New York Medical Journal, 1876, p. 608.
19	Dr. P. Dupuytren.	Right.	....	44	Aneurism.	1	......	Pacific Med. and Surg. Jour., August, 1872.
20	Dr. G. E. Frothingham.	....	....	......	Orbital aneurism.	1	......	Michigan University Med. Jour., August, 1872.

No.	Operator and Date.	Side.	Sex.	Age.	Disease.	Recoveries.	Deaths.	Reference and Remarks.
21	Dr. W. H. Bramlett.	Left.	....	......	Shot wound of the face.	1	......	New York Medical Record, 1869, '70, iv. 194.
22	H. Lee.	Right.	Male.	40	Aneurism.	......	1	St. George's Hospital Reports, 1870, v. 277.
23	H. Lee.	Left.	"	31	Tumor of the neck.	1	......	St. George's Hospital Reports, 1871, '72, vi. 384.
24	T. Holmes.	Right.	"	50	Thoracic aneurism.	......	1	St. George's Hospital Reports, 1871, '72, vi. 387.
25	Pick (3).	....	"	19	Ulceration of lingual artery.	......	1	St. George's Hospital Reports, 1872, '74, viii. 309.
26	T. Holmes.	Left.	Female.	21	Aneurism of the arch of the aorta.	1	......	Clinical Society's Transactions, 1876, ix. 114.
27	Dr. J. C. Hutchison.	Right.	Male.	48	Aneurism of the arch of the aorta.	......	1	New York Medical Record, 1867, '68, ii. 265. Carotid and subclavian tied.
28	E. Colsen, Bombay Army.	Left.	"	48	Aneurism of the external carotid.	1	......	Lancet, February 24, 1877.
29	Fred. Ensar, Surgeon Port Elizabeth Hospital, South Africa.	Right.	"	50	Aneurism of innominate.	......	1	Lancet, February 6 and July 31, 1875. Carotid and subclavian tied.
30	C. F. Maunder, September 18, 1867.	Left.	"	37	Aneurism of innominate.	.. ...	1	Lancet, January 9, 1875.
31	C. F. Maunder, September 22, 1868.	"	"	26	Aneurism.	1	......	Lancet, January 9, 1875.
32	Mr. G. E. Legge Pearce	Right.	"	55	Cancer of tongue.	1	......	Lancet, March 16, 1872, p. 357.
33	Dr. Marquardt, of Thorn.	"	"	......	Stab in the neck.	1	......	Allg. Med. Central Zeit., December 1, 1869.
34	Mr. J. Wright Baker.	Left.	Female.	32	Hemorrhage following removal of a tumor of the neck.	1	......	Lancet, June 11, 1870.
35	Mr. H. Knowles.	Right.	Male.	42	Innominate aneurism.	......	1	Lancet, June 13, 1868, p. 750.
36	Prof. Richet.	Left.	Female.	63	Orbital aneurism.	.....	1	Annales d'Oculistique, 1869, t. 61, p. 186.
37	Dr. Schmidt.	Right.	Male.	23	Orbital aneurism.	1	......	Odessa Klin. Monatsschr., 1871, ix. 219.
38	Dr. Gurdon Buck, 1857, 1859.	R. & L	"	22	Orbital aneurism, traumatic.	1	......	New York Medical Journal, 1869, p. 664.
39	Dr. Halstead.	Left.	"	37	Orbital aneurism, traumatic.	1	......	New York Medical Journal, 1869, p. 665.
40	F. M. Carner.	Right.	"	33	Orbital aneurism.	1	......	Trans. Hunterian Soc., 1874.
41	Nélaton.	Left.	Female.	17	Orbital aneurism, traumatic.	......	1	Lancet, 1873.
42	Schiess, Gemuseus, and Socin.	"	"	40	Orbital aneurism, traumatic.	1	......	Klin. Monat. für Augenheilk., vol. viii. p. 57, 1870.
43	Drs. A. V. Hippel and Schonborn.	Right.	Male.	21	Orbital aneurism, traumatic.	1	......	Graefe's Arch. für Ophth., Bd. xx., Abth. 1, 1874.
44	Dr. Rivington.	Left.	"	24	Orbital aneurism, traumatic.	1	......	Medico-Chirurgical Transactions, 1875.
45	Dr. Niedeu.	"	"	19	Orbital aneurism, traumatic.	1	......	Klin. Monat. für Augenheilk., Jan. Heft, 1875.
46	Dr. Gervasé.	Right.	"	34	Orbital aneurism by anastomosis.	1	......	Della Chirurgia in Italia, etc., di Alfonso Carrudi, Bologna, 1871, p. 131.
47	Mr. Thos. Annandale, March 2, 1875.	"	"	62	Orbital aneurism.	1	......	British Medical Journal, October 30, 1875.
48	Dr. Eugene Peugnet.	R. & L.	"	......	Osteo-aneurism of inferior maxilla.	......	......	New York Medical Record, February 5, 1876.
49	Dr. G. E. Frothingham.	Right.	"	23	Traumatic aneurism.	1	......	Am. Jour. Med. Sci., Oct. 1876, p. 433.
50	Dr. J. Elliot.	"	"	41	Innominate aneurism.	......	1	Am. Jour. Med. Sci., April, 1877. Subclavian artery also tied.
51	Mr. Le Gros Clark, June 17, 1872.	Left.	"	57	Hemorrhage after removal of a cancer of antrum.	......	1	Medical Times and Gazette, February 1, 1873, p. 113.
52	G. Annesley, Dr. Mahon.	Right.	....	......	Wound of superior laryngeal artery.	1	......	British Medical Journal, April 10, 1869, p. 329.
53	Mr. James Lane, November 12, 1873.	Left.	"	37	Occipital aneurism, traumatic.	1	......	British Medical Journal, May 15, 1875.
54	Mr. Savory, July 17, 1872.	Right.	"	48	Secondary hemorrhage from external carotid	......	1	British Medical Journal, February 22, 1873.
55	Mr. E. S. O'Grady.	"	....	......	Subclavian aneurism.	......	1	Brit. Med. Jour., May 10, 1873, p. 543. Innominate and right carotid tied.
56	Mr. S. Gambee.	Left.	....	......	Aneurism, innominate.	......	1	British Medical Journal, May 27, 1871, p. 566.
57	T. Morton, 1874.	"	Female.	23	Supposed intraorbital aneurism.	......	1	Am. Jour. Med. Sci., April, 1876.
58	T. Morton, 1876.	"	Male.	43	Pulsating orbital tumor.	......	1	Am. Jour. Med. Sci., April, 1876.
59	Dr. B. M. Smith, 1877.	"	....	......	Wound of external carotid.	1	......	Virginia Medical Monthly, October, 1877.
						38	20	

Of the above 59 ligations, 25 were on the right side, 28 on the left, 2 on both sides, and in 4 the side is not stated; 35 were males, 7 females, and in the remaining number the sex is not stated; 38 recovered, 20 died, and in 1 no result is given. The causes rendering the ligation necessary were aneurism, spontaneous and traumatic,—15 being intraorbital,—cancer of the maxillæ and of the tongue, hemorrhage attending the removal of tumors from the neck, shot wounds of the face, and wounds of the lingual and laryngeal arteries.

The period of separation of the ligature from the vessel varies from the ninth to the twentieth day.

Ligation of both primitive carotids.—This operation has been done twenty-eight times, with 20 recoveries and 8 deaths. In one case, Dr. Mott, for disease of the parotid gland, tied both common carotids at an interval of fifteen minutes. The patient died in forty-eight hours, in a state of coma.

The diseases for which double consecutive ligation has been performed are erectile growths of the head and face, vascular tumors of the orbits, epilepsy, hemorrhage, and elephantiasis of the neck and face. It does not appear that in these cases of double ligation cerebral symptoms occurred more frequently than when only the vessel on one side was tied. The circumstances which justify its performance will seldom arise. As a means of curing angeiomatous growths about the head and face, or of combating epilepsy, it possesses little value. Seldom will the surgeon encounter a case of bilateral orbital aneurism; so that its utility is narrowed down to cases of hemorrhage, in which, being the only resource of the surgeon, it is entirely justifiable.

The subjoined table contains all the recorded cases of the ligation of both common carotid arteries:

Table of Ligations of both Primitive Carotid Arteries.

Name of Operator.	Age.	Disease.	Date and Interval of Ligations.	Result.
1. Dupuytren and Robert.	......	Aneurism by anastomosis of the scalp.	Dupuytren tied the right carotid in 1819. In 1857 Robert tied the left carotid, in consequence of an increase in the disease. Interval, thirty-eight years.	Death from cerebral symptoms; paralysis on one side.
2. Magill.*	......	Vascular tumors of both orbits.	1823. One month between the ligations.	Recovered.
3. Ullman.	20	Erectile tumor of the orbit.	Left ligated in 1823; right, the following year.	Death from hemorrhage on the third day.
4. Mussey.†	20	Aneurism by anastomosis of the scalp.	Left tied Sept. 20; right tied Oct. 2, 1827; twelve days between.	Recovered.
5. Mussey.	19	Aneurism by anastomosis of the scalp.	Twenty-eight days between ligations.	Recovered.
6. Möller.	4½	Erectile tumor.	One carotid tied Sept. 13, and the other Sept. 28, 1831.	Recovered.
7. Langenbeck.	......	Hemorrhage following ligation of the superior thyroid.	....	Died the following day.
8. Preston.	50	Epilepsy.	Right tied Aug. 23, 1831; left tied Nov. 14 of the same year.	Recovered.
9. Kuhl.	53	Anastomotic aneurism of the scalp.	Left tied May 24, 1834; right tied seventy-two days afterwards.	Recovered. Operation was followed by cerebral symptoms and hemorrhages.
10. Hamilton.	18	Epilepsy.	Right tied Aug. 1838; left tied March, 1839.	Recovered, though the last operation was followed by paralysis of the tongue and by disorganization of the left eye.

* New York Medical and Physical Journal, vol. iv. p. 576.
† American Journal of the Medical Sciences, vol. v. p. 316.

Table of Ligations of both Primitive Carotid Arteries.—(Continued.)

Name of Operator.	Age.	Disease.	Date and Interval of Ligation.	Result.
11. Velpeau.	29	Anastomotic aneurism of both orbits.	Right tied Aug. 1839; left tied three months afterwards.	Recovered.
12. Pirogoff.	20	Hemorrhage from an anastomotic aneurism of the scalp.	Left tied May 16, 1843; right tied June 9, 1844.	Recovered; cerebral symptoms following each operation.
13. Mott.	......	Malignant disease of the parotid glands.	Fifteen minutes between the operations.	Died in twenty-four hours, from coma.
14. Mott.	......	Epilepsy.	Six months between the operations.	Recovered.
15. Ellis.	......	Secondary hemorrhage following gunshot wound.	Interval of four and a half days.	Recovered.
16. J. M. Warren.	23	Erectile tumor affecting face, mouth, and neck.	Oct. 5, 1845, tied the left; Nov. 7 of the same year, tied the right.	Recovered.
17. Robert.	......	Aneurism by anastomosis of the scalp.	Tied the left June 5, 1846; the right Feb. 22, 1847.	Recovered. Operation was followed by cerebral symptoms and temporary loss of vision.
18. Blackman.	15	Vascular growth of the antrum and the nose.	Twenty-one days between the ligations.	Recovered. Temporary loss of vision in the left eye.
19. Reynolds and Van Buren.	45	Aneurism by anastomosis.	Right tied in 1844; left tied in 1850.	Recovered.
20. W. Parker.	42	Malignant disease of the antrum.	Thirty-two days between the operations.	Death.
21. J. R. Wood.	53	Malignant disease of the antrum.	Right tied July 18, 1856; left tied Dec. 26 following.	Death on the sixtieth day. There was delirium, with other signs of constitutional disturbance.
22. Weber.	20	Epilepsy.	Left tied July 18, 1856; right tied Dec. 2 following.	Recovered, though the disease was not cured.
23. Dr. Gurdon Buck.*	22	Intraorbital aneurism.	Right carotid tied in 1857; left carotid tied in 1859; two years between the operations.	Recovered.
24. Carnochan.	44	Elephantiasis of the face and neck.	Right tied Nov. 1858; left tied June, 1859.	Recovered. Disease not cured, though improved.
25. Murdock, P.A. C.S.†	.....	Hemorrhage after shot wound of the neck.	Left tied May 12, 1863; right tied May 15, 1863.	Died.
26. Billroth.	27	Hemorrhage from syphilitic ulceration of the carotid, consequent on caries of the temporal bone.	Right tied Dec. 13, 1864; left tied Dec. 26 following.	Died from secondary hemorrhage.
27. Buenger.	34	Aneurism by anastomosis; suicidal wound.	Left first tied, and for the aneurism; five years after, the right, for wound.	Recovered, with the loss of the right eye.
28. Foot.‡	20	Orbital aneurism.	Thirty days between the operations.	Recovered. Disease cured.

* New York Medical Journal, 1869, p. 664.
† Surgical History of the War of the Rebellion, Part I., p. 421.
‡ New York Medical Record, 1868, vol. iii. p. 75.

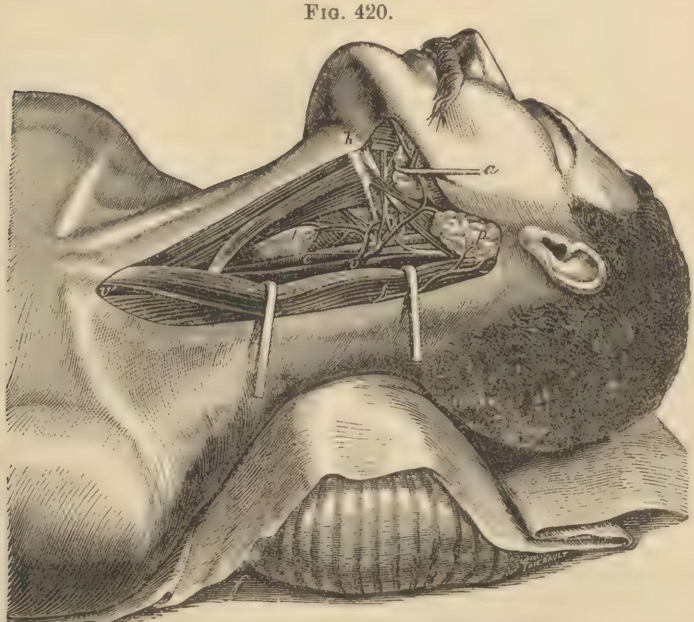
History of the ligation of the primitive carotid artery.—Mr. Abernethy has generally been credited with having first performed this operation, in 1798. Hebenstreit, however, refers to an earlier operation, a case in which a surgeon, in removing a malignant growth from the neck, wounded the common carotid, on account of which he tied the artery. He does not mention the name of the operator, nor does he state that he witnessed the accident which gave rise to the ligation, or that any record of the fact had been made.

The necessity for the operation in Abernethy's case arose from a wound of the neck, inflicted by the horn of an infuriated cow. Mr. Fleming,* in 1803, made the first successful ligation of the common carotid, for a self-inflicted wound of the neck. In 1805 this vessel was first tied by Sir Astley Cooper for aneurism, and in 1808 it was again tied by the same surgeon. The first operation was unsuccessful, the patient dying on the thirteenth day. The second was followed by recovery. The following year, 1809, the vessel was ligated by Travers for orbital aneurism, with entire success.

Ligation of the External Carotid and its Branches.

Surgical anatomy.—The external carotid artery and its branches, together with the internal carotid, all lie in the anterior superior cervical triangle,—that is, in the space which is bounded externally by the anterior border of the sterno-cleido-mastoid muscle, internally by the median line of the neck,

Fig. 420.



The anatomical components of the anterior superior cervical triangle. The retractors draw aside the sterno-mastoid muscle and expose the primitive and the external carotid and its branches; also the internal jugular, *v*, with its tributaries, the facial, lingual, and pharyngeal; *p*, parotid gland; *h*, os hyoides, to which is attached the stylo-hyoid muscle, through which is seen running the tendon of the digastric, under which passes the hypoglossal nerve, after crossing the external carotid; *a*, hook raising the submaxillary gland in order to expose the contiguous parts.

above by a line extending from the mastoid process of the temporal bone along the base of the jaw to the chin, and below by the intersection of the omo-hyoid muscle with the sterno-mastoid, the latter point being the apex of the triangle. (Fig. 420.) The course of the external carotid is from the superior border of the thyroid cartilage, upwards and backwards, to the deep

* Medico-Chirurgical Journal, vol. iii. p. 50.

sulcus behind the angle of the jaw, occupied by the parotid gland, underneath which it passes, ascending to the neck of the condyle of the lower maxillary bone, where it divides into its internal maxillary and temporal branches. Except it be the first part of the subclavian artery, no other vessel is surrounded with such a throng of closely-packed structures. In front will be found the skin, superficial fascia, platysma myoides, deep fascia, lymphatic glands, lingual and facial veins, hypoglossal nerve and digastric and stylo-hyoid muscles; behind are placed the superior laryngeal and stylo-pharyngeus muscles; and internally are the hyoid bone and the pharynx. (Fig. 420.) I do not speak of the anatomical relations of the artery within the limits of the parotid regions, where, except in case of wounds or in removing the parotid gland, the vessel is not the subject of ligation.

It may become necessary to ligate the external carotid in consequence of a wound of the vessel, or for the cure of an aneurism affecting one of its branches. When done for the arrest of hemorrhage, the thread should be placed on both sides of the lesion. Mott tied this artery while removing the inferior maxillary bone, and Lizars also, in an operation for the excision of the superior maxillary. In cut-throat cases, where one of the branches of the external carotid is wounded, and where, in consequence of the extravasated blood in the tissues of the neck, it may be found difficult to discover the bleeding vessel, the surgeon may be tempted, as the easiest task, to tie the parent trunk. The operation, however, is by no means reliable. The free anastomosis which exists between the branches of the two sides would most probably be followed by a recurrence of the hemorrhage. On this account the double ligation of the wounded vessel should be deemed the only safe practice, and this, with a little patience, can generally be accomplished. If, however, a different course should be adopted, namely, that of tying the external carotid on one side, in consequence of a wound, for example, of the superior thyroid, and secondary hemorrhage should follow, in the event of not being able to find the bleeding branch it would be proper to tie the external carotid of the opposite side.

Operation.—The patient should be placed in the same position as that directed for the ligation of the common carotid. An incision should be made, commencing midway between the angle of the jaw and the anterior border of the sterno-mastoid muscle, and carried down three-eighths of an inch in front of the latter, to a point half an inch below the upper border of the thyroid cartilage. (See line of incision, Fig. 417.) The skin, superficial fascia, platysma, and deep fascia being carefully laid open,—the last three layers upon the director,—the operator will encounter the facial and lingual veins, and frequently one or two glands. If these cannot be readily pressed aside, it will be best to pass a needle, armed with a thread, at two points underneath these trunks, and divide them between the threads. At this stage the vessel may be discovered crossed by the hypoglossal nerve and the stylo-hyoid and digastric muscles. It should now be carefully isolated by the director from the internal carotid and the internal jugular, both of which lie close along its outer side. The contracted space in which the surgeon is obliged to work renders this part of the operation one of great delicacy to avoid inflicting some injury on the vein. After being satisfactorily separated from the surrounding parts, the vessel should be raised by passing the needle between the two carotids, and from without inward, when the ligature can be detached and tied.

Ligation of the external carotid, when considered in the light of M. Guyon's statistics,* has proved a much more successful operation than could possibly have been expected from the anatomical peculiarities of the vessel. Of 19 cases collected by the writer in which this artery was tied, only one proved fatal from hemorrhage, and none from causes which could properly be attributed to the operation.

* Mémoires de la Société de Chirurgie, 1863, t. vi. p. 197.

Ligation of the Superior Thyroid.—The superior thyroid is the first branch given off by the external carotid, and leaves the vessel about one-quarter of an inch below the great horn of the hyoid bone. Its course is upwards, inwards, and downwards, describing a curve before reaching its destination in the thyroid body. The vessel is covered in front by the skin, superficial fascia, platysma myoid, deep cervical fascia, and a few small veins. Before entering the thyroid body it divides into several branches, which pass beneath the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles.

The vessel may require to be ligated in case of suicidal or other wounds, and it has been tied with a view to diminish a hypertrophied thyroid gland. Only a single case is noted during the War of the Rebellion in which this artery was tied.*

Operation.—An incision along the anterior edge of the sterno-mastoid muscle should be made, similar to that for exposing the external carotid, though it need not commence quite so high in the neck. The skin, superficial fascia, platysma myoid, and deep fascia being divided, search should be made by the director in the deep sulcus between the upper extremity of the larynx and the great vessels of the neck. When discovered and denuded, the needle should be passed round the vessel from above downwards, and with the point somewhat directed towards the thyroid body, in order to avoid any injury to the carotid.

Ligation of the Lingual Artery.—This operation is one of the most difficult of all ligations.

Surgical anatomy.—The artery is the second branch furnished from the anterior aspect of the external carotid. It leaves the parent vessel about a quarter of an inch above the superior thyroid, nearly opposite the great horn of the hyoid bone. It first ascends above the level of the latter, and then curves abruptly downwards and inwards, and, passing underneath the outer margin of the hyoglossus muscle, runs parallel with and close to the superior cornu of the hyoid bone, finally ascending to the tongue, along the under surface of which it extends from the base to the tip of the organ.

The artery may be divided into three regions: the first, external to the hyoglossus muscle, the second, beneath the muscle, and the third, from the inner margin of the latter to the tip of the tongue. The vessel is deeply situated in its entire course. Were it not that the hyoid, dorsalis linguæ, and the sublingual branches are given off in the second part of its course, the third portion of the vessel, where it is placed between the hyoglossus and genio-hyoglossus muscles, would be the most convenient situation for its ligation, as it could be reached by an incision in the median line of the neck below the chin: by this route fewer important structures would be encountered. The second part of the artery, or that under the hyoglossus muscle, is the portion which has been uniformly selected for ligation.

In front of the vessel are the skin, superficial fascia, platysma myoid, deep fascia, the inferior border of the submaxillary gland, a second leaf of the deep fascia which passes beneath the gland and completes its capsule, the facial, superficial lingual, and pharyngeal veins, the stylo-hyoid and digastric muscles, the hypoglossal nerve, and the hyoglossus muscle. The artery rests upon the middle constrictor of the pharynx, and lies immediately (about one line) above and parallel with the great horn of the hyoid bone. (Fig. 421.) Difficult as is the approach to the vessel, no artery in the body possesses so many landmarks to guide the operator.

The operation of tying the lingual artery has been performed for wounds of the tongue, for suicidal wounds, and for the arrest of malignant growths. Mr. Moore, Surgeon to the Middlesex Hospital,† in one case of cancer of the tongue, ligated this artery, with a view to reduce the amount of blood carried to the ulcer, supposing that it might be an important palliative auxiliary to the

* Surgical History of the War of the Rebellion, Part I., surg. vol., p. 397.

† Medico-Chirurgical Transactions, vol. xlv. p. 56.

division of the gustatory nerve, as practiced by Mr. Hilton and by himself in a number of cases of malignant disease of the tongue.

M. Demarquay* has written a very interesting article on the ligation of this artery. Both lingual arteries were simultaneously tied during the War of the Rebellion for a shot wound of the tongue accompanied with a fracture of the jaw.† The patient survived, but was totally disabled by ill health.

Fig. 421.

Relations of the lingual artery: *H*, hyoid bone; *h*, its great horn; *M*, the body of the lower jaw; *M'*, its angle; *sh*, *oh*, *th*, insertions, into the body and horn of the hyoid bone, of the sterno-hyoid, omo-hyoid, and thyro-hyoid muscles; *ph*, the inferior constrictor muscle of the pharynx; *sm*, the submaxillary gland drawn over the jaw, with (*f*) the facial artery and vein; *je*, the external jugular drawn aside, along with the sterno-cleido muscle; *d*, the digastric muscle perforating the stylo-hyoid muscle, and looped down to the great horn of the hyoid bone by its fibrous pulley, *d'*; *hyp*, hypoglossal nerve running forward alongside of the lingual vein, and disappearing under (*mh*) the mylo-hyoid muscle; *l*, the lingual artery passing beneath (*hy*) the hyoglossus muscle; *t*, the superior thyroid artery; *f*, the facial artery, behind which lies (*ce*) the external carotid; *ci*, the internal carotid artery; *ji*, the internal jugular vein, into which are seen emptying the facial, the lingual, and the superior thyroid tributaries. The white stars mark the point where the lingual artery should be tied.

Operation.—The patient should be placed on the back, with the head turned a little to the opposite side and well extended, so as to amplify the space between the hyoid bone and the base of the jaw. The surgeon now feels for the great horn of the hyoid bone, and, having ascertained its position, begins his incision at the anterior border of the sterno-cleido-mastoid muscle, half an inch above a point opposite to the extremity of the great horn of the bone, and, carrying it forward and a little downwards so as to give it a slight curve with the convexity below, terminates the cut three-quarters of an inch short of the median line of the neck, and half an inch below the base of the jaw. (Fig. 417.) This incision, I am convinced from having very many times practiced it upon the cadaver, admits of the most satisfactory exposure of the parts associated with the artery. The head *must* be maintained rigidly in the same position from the beginning to the end of the operation. Any material change in this respect, especially in the direction of flexion, will alter all the details of the procedure. All incisions should be made in a forward direction, or away from the great blood-vessels of the neck, which lie close to the posterior extremity of the wound. The skin, and the connective and adipose tissues, being divided, the first layers of the deep fascia, or the anterior part of the capsule of the submaxillary gland, will appear. This must be raised upon the director and laid open, when the gland will be exposed. With the finger, or the handle of the scalpel, this body should be detached from its deep connections and drawn forward over the jaw, great care being taken in doing so that the facial artery and vein, which pass through its substance, are not injured. These being pressed out of the way, the thin posterior leaf of the capsule of the submaxillary gland must be divided, when there will be exposed the white, shining aponeurosis which loops the digastric tendon to the great horn of the hyoid bone, and also the insertion of the stylo-hyoid muscle, after a little more clearing away of loose connective and adipose tissue. Immediately behind these will, most probably, be seen the hypoglossal nerve, three lines above the cornu of the bone, and running across the hyoglossus muscle, forward and upwards, towards the middle of the jaw. The cellular tissue, which holds

* Gazette Médicale de Paris, 1867, p. 634.

† Surgical History of the Rebellion, Part I., surg. vol., p. 397.

the nerve in contact with the sheath of the hyoglossus muscle, should now be scratched through with the edge of the knife, and the former pushed up out of the way, as below this nerve runs the artery. All that is now necessary for the denudation of the artery is to fix the hyoid bone by inserting a tenaculum into the digastric aponeurosis, and by carefully insinuating the point of the director underneath the posterior margin of the hyoglossus muscle and pushing it forward close along the upper border of the great horn of the hyoid bone, to separate this muscle from the middle constrictor of the pharynx behind. If now the fibres of the hyoglossus be divided, the artery will be exposed, when it can be raised by passing the needle from above downwards, in order to avoid injury to the hypoglossal nerve. Occasionally it may be necessary to divide a few fibres of the stylo-hyoid muscle, when its insertion extends far back. It is sometimes advised to raise the fibres of the hyoglossus muscles with the forceps, and by light touches with the edge of the knife, from before backwards, gradually uncover the artery. At every step of the operation, after passing the superficial fascia, the operator should shape his course by thrusting a finger into the wound and feeling for the great horn of the hyoid bone. There are, therefore, three important guides to reveal the situation of the lingual artery, namely, the pulley of the digastric tendon, and the great horn of the hyoid bone, both of which lie immediately below the vessel, and the hypoglossal nerve, which is placed immediately above the lingual artery and separated from it by the hyoglossus muscle.

Ligation of the Facial Artery.—The facial artery is frequently the subject of ligation, in consequence of operations upon the face, the jaws, and the neck. Its superficial position where it emerges from the neck and passes over the jaw in front of the masseter muscle renders it quite easy, by making pressure at this point, to control hemorrhage during operations upon different parts of the face. The facial artery is remarkable for its tortuous form, both in the neck and on the face, a peculiarity well adapted to the ever-varying movements of these regions. The vessel after reaching the face passes to the angle of the mouth, and from thence up along the side of the nose to the internal canthus of the eye, where it communicates, as the angular artery, with the supraorbital branch from the ophthalmic.

Surgical anatomy.—The facial artery is divided into a cervical and a facial region.

In the cervical region, the vessel, after leaving the external carotid a short distance above the lingual, runs obliquely forward and upwards, under the shelter of the inferior maxillary bone, passes beneath the stylo-hyoid and digastric muscles and the submaxillary gland, and bends abruptly towards the surface, in order to reach the face.

It is consequently covered in front, while occupying the supra-digastric or submaxillary space, by the skin, the subcutaneous, connective, and adipose tissues, the platysma myoid, the deep fascia, and the submaxillary gland; it is accompanied by the facial vein.

The facial portion of the vessel reaches the face by passing from the neck over the base of the inferior maxillary bone, which possesses, immediately in front of the masseter muscle, a slight groove for the accommodation of the artery. Between the latter and the artery is placed the facial vein, which, after passing farther up on the face, becomes considerably separated from the artery.

Over the jaw the vessel is very superficial, being covered only by the skin, superficial fascia, the platysma myoid, and a thin layer of the deep cervical fascia.

The vessel may demand ligation in consequence of wounds of the neck, accidental or designed, and also during the removal of tumors from the submaxillary region.

During the War of the Rebellion the facial artery was tied five times for hemorrhage following shot fractures of the lower jaw.

The vessel may be ligated either in its cervical or in its facial portion.

Operation.—The ligation in the first-named region, though condemned by Manec on account of its depth, is not a difficult task after the artery has entered the submaxillary space. An incision similar to that for exposing the lingual vessel should be made, only differing in the following particulars: it should be made a little higher or nearer to the base of the jaw, and it need not be carried so far anteriorly. Upon dividing the layers overlying the submaxillary gland, and hooking up the latter with the finger, the artery will be drawn out, in consequence of its fibrous tissue connection with the gland, when it can be easily separated from the vein and surrounded by a thread.

The ligation of the facial portion of the artery is a very simple procedure. An incision is made one inch in length over the inferior maxillary bone in front of the masseter muscle. (See Fig. 417.) The pulsation of the vessel can be readily discovered by inserting a finger into the wound, the jaws being at the same time closed. By dividing the subcutaneous, connective, and adipose tissues, the platysma myoid muscle, and the deep fascia, the vessel will be uncovered (Fig. 422), and after being separated from the vein on its outer side, should be raised on the needle, which is to be passed between the vein and the artery and carried from without inwards.

Ligation of the Occipital Artery.—The occipital artery arises from the external carotid, opposite the facial, and passes backwards and upwards, dipping under the posterior belly of the digastric and stylo-hyoid muscles, and under the lower part of the parotid gland, at which place it is crossed by the hypoglossal nerve. A little above this point the vessel runs over the internal carotid artery, the internal jugular vein, and the pneumogastric and spinal accessory nerves. Changing its direction, the artery ascends the neck to the level of the transverse process of the atlas, where it again takes a horizontal course, passing through a groove on the mastoid portion of the temporal bone, and, after passing under the sterno-mastoid, splenius, digastric, and trachelo-mastoid muscles, pierces the insertion of the splenius capitis, and is distributed to the posterior part of the scalp.

The occipital artery may require ligation either on account of wounds or for the cure of aneurism.

Operation.—The ligation of the *cervical portion* of the occipital is an operation which demands both anatomical knowledge and surgical skill. The incision should be made along the anterior border of the sterno-cleido-mastoid muscle, beginning between the lobe of the ear and the ramus of the jaw, and prolonged downwards two inches and a half. (See Fig. 417.) At the upper angle of the wound the integument, and the subcutaneous, connective, and adipose tissues, alone should be incised. The deep or parotid fascia in this situation must not be opened, otherwise a salivary fistula will be likely to follow. At the lower part of the parotid gland the deep fascia may be incised, after which the finger can be carried beneath the gland and the latter be drawn outwards and upwards. A retractor being now placed beneath the anterior edge of the sterno-mastoid muscle, the latter should be pulled outwards, thus exposing a deep fossa, at the bottom of which will be seen the digastric and stylo-hyoid muscles. These being pushed upwards, the occipital artery may be seen crossing the internal carotid vessel and the internal jugular vein, and resting in the curve formed by the cord of the hypoglossal nerve as it abruptly turns across the neck; immediately behind which will be the most convenient point to incise the artery and to encircle it with a ligature. In doing this the needle should be passed from without inwards, so as not to damage the jugular vein.

The ligation of the *occipital portion* of the artery is a much less difficult operation than that just described.

An incision, nearly horizontal, should be made, two inches in length, commencing at the apex of the mastoid process of the temporal bone, and ex-

tending backwards and very slightly upwards. (See Fig. 417.) The operator divides consecutively the skin and subcutaneous tissue, the outer border of the sterno-mastoid muscle and its aponeurotic expansion, the splenius, and finally the complexus. Search must now be made for the artery, by introducing a finger into the inner angle of the wound, when it may by the pulsation be detected between the mastoid process of the temporal bone and the transverse process of the atlas, from which point it can be traced externally to a more superficial position, in the direction of the splenius muscle, where it may be isolated from the occipital vein and tied. (Fig. 422.) If the vessel be denuded near to the mastoid process, unusual care will be demanded not to damage the large mastoid tributaries which join the occipital vein in this locality and establish a communication between the latter and the lateral sinus of the brain.

Fig. 422.

The facial, occipital, and temporal arteries exposed, and the threads passed beneath these vessels.

Ligation of the Temporal Artery.—The temporal artery is the continuation of the external carotid. The vessel after emerging from beneath the upper part of the parotid gland crosses the zygoma immediately posterior to the condyle of the inferior maxillary bone, and one-fourth of an inch in front of the cartilage of the ear. About one inch and a half above the zygoma the artery divides into the anterior and posterior temporal branches.

The surgical relations of the vessel are quite simple. It is covered by the skin, superficial fascia, attrahens auris muscle, a loose connective tissue formed from the parotid and temporal regions, and a lymphatic gland. The temporal vein lies on the auricular side of the artery, and on both its anterior and posterior aspects run nerves, viz., the temporal branches of the facial, and the auriculo-temporal from the inferior maxillary.

In former times the operation of arteriotomy was frequently practiced on the temporal artery, or on one of its branches. The ligation of the vessel may be rendered necessary on account of wounds, or in cases of aneurism.

Operation.—Between the cartilage of the ear and the condyle of the jaw make a vertical incision one inch in length (see line on Fig. 417, showing the line for the operation). After dividing the skin, the superficial fascia, and some fibres of the attrahens auris muscle, the operator will come upon the loose connective tissue which envelops the artery, veins, and nerves, and probably a small lymphatic gland. It is generally thought best to ligate the vessel a short distance above this, as, in the event of suppuration following the operation, there would be less probability of the pus burrowing in the contiguous parts, a result certainly to be anticipated if this fibrous capsule were opened. The strength of the fibrous bands which surround the artery necessitates the exercise of considerable force to effect its complete isolation. After accomplishing this, the needle, or any other instrument used for introducing the thread, should be passed from the ear towards the orbit, counterpressure being made with the finger, and a close scrutiny instituted to see that no nerve-filament has been included in the loop of the thread. (Fig. 422.)

Ligation of the Internal Carotid Artery.

Ligation of the internal carotid, except in cases of a wound of that vessel, is an operation which has been abandoned; and even when contemplated for hemorrhage occurring in the region of this artery, it will be better, in view of the great uncertainty attending the true source of such bleeding, to tie the primitive carotid. In a shot wound of the face, Dr. W. H. Bramlette, of Virginia, tied the external, internal, and common carotid arteries.* In an open wound of the neck, and when the injury to the internal carotid is unmistakable, the ligature should, of preference, be applied to the damaged vessel, and on both sides of the lesion. The rapidity, however, with which death follows such accidents renders it very improbable that the services of the surgeon can be sufficiently prompt to avail for the rescue of his patient. If such an operation were deemed advisable, the same incision as that required for the ligature of the external carotid would be demanded; remembering, at the same time, on reaching the cellular envelope of the blood-vessels, that the internal carotid is the external of the two arteries, and that on passing the needle the point of the instrument should be directed from the internal jugular, that is, from without inwards, and that it be so guided by the finger as not to injure the external carotid, which lies to the inner side.

Ligation of the Subclavian Artery.

The ligation of the subclavian artery was first attempted by Sir Astley Cooper, in 1809.† The case was one of aneurism, and was attended with such displacement of the clavicle and adjoining parts that the operation was found impracticable and had to be abandoned. The same year, however, it was accomplished by Ramsden for aneurism of the axillary artery. The patient survived five days. In 1811, Sir William Blizard, and in 1815, Thomas Blizard,‡ each tied the subclavian. Both patients died. Dr. Colles,§ in 1815, performed the operation, but without success. On the 8th of September, 1817, Dr. Post, of New York, made the first successful ligation of this vessel, and in 1820 Mr. Liston was equally fortunate in a case of subclavian deligation. Since that time the artery has been many times tied, with results which will be hereafter stated.

Surgical anatomy.—The subclavian artery, in its course from the source of its origin to the first rib, is crossed by the scalenus anticus muscle, and thereby divided into three surgical regions: the first, from its origin to the inner border of the scalenus anticus muscle; the second, that part beneath or covered by this muscle; and the third, the remaining portion of the vessel from the external margin of the scalenus muscle to the first rib. It is rare for either the first or the second part of the vessel to become the subject of operation.

In consequence of the difference in origin of the arteries on the two sides, the surgical relations of the first portions of the vessels are not identical.

First region.—On the right side, the subclavian artery, coming from the innominate, begins under the sterno-clavicular articulation, and runs upwards and outwards to the inner edge of the scalenus anticus. In front lie the skin, the superficial fascia, the platysma, the deep fascia, the clavicular origin of the sterno-cleido-mastoid, sterno-hyoid, and sterno-thyroid muscles, and a second leaf of the deep cervical fascia. It is also crossed by the internal jugular and vertebral veins, and by the pneumogastric, cardiac filaments of the sympathetic, and phrenic nerves. Behind the artery lie the longus colli, the transverse process of the seventh cervical vertebra, the sympathetic nerve, and, to some extent, the recurrent laryngeal

* New York Medical Record, 1869–70, vol. iv. p. 294.

† London Medical Review, vol. ii. p. 300.

‡ Hodgson on the Arteries.

§ Edinburgh Medical and Surgical Journal, vol. xvi. p. 348.

nerve. The thoracic surface of the vessel is in contact with the pleura, and below is situated the subclavian vein.

The first portion of the left subclavian artery, coming from the arch of the aorta, is a longer and deeper vessel than the right; it rises almost vertically into the neck, instead of forming a gradual curve like the vessel on the opposite side. It is covered in front by the skin, the subcutaneous connective tissue, the platysma myoid, the deep cervical fascia, the sterno-cleido-mastoid, sterno-hyoid, and sterno-thyroid muscles, the pneumogastric, the phrenic and cardiac branches of the sympathetic nerve, the internal jugular and innominate veins, the pleura, the lung, and the left carotid artery. Posteriorly are placed the œsophagus, the thoracic duct, the sympathetic nerve, and the vertebral column, with the longus colli interposed. On the inside are the œsophagus, the trachea, and the thoracic duct; and on the outside is the summit of the pleura.

The relations of the second and third portions of the two subclavian arteries are alike.

Second region.—The second portion of the artery has in front the skin, the superficial fascia, the platysma, the deep fascia, the clavicular head of the sterno-cleido-mastoid, a second layer of the cervical fascia, the scalenus anticus with its dense sheath, the phrenic nerve, and the subclavian vein. Posteriorly, the artery rests upon the scalenus medius; above are the cords of the brachial plexus of nerves, and below is the pleura.

Third region.—This region is the most important from a surgical point of view; it is the region of election, and embraces both the greatest extent of the artery and its most accessible position. It corresponds to the posterior inferior cervical triangle, a space which is bounded anteriorly by the posterior border of the sterno-cleido-mastoid muscle, superiorly by the omo-hyoid muscle, externally by the inner edge of the trapezius muscle, and inferiorly by the clavicle and the first rib. In the undissected neck there is a marked depression above the clavicle, over the region, which is sometimes termed the supra-clavicular fossa, and at other times the subclavian fossa.

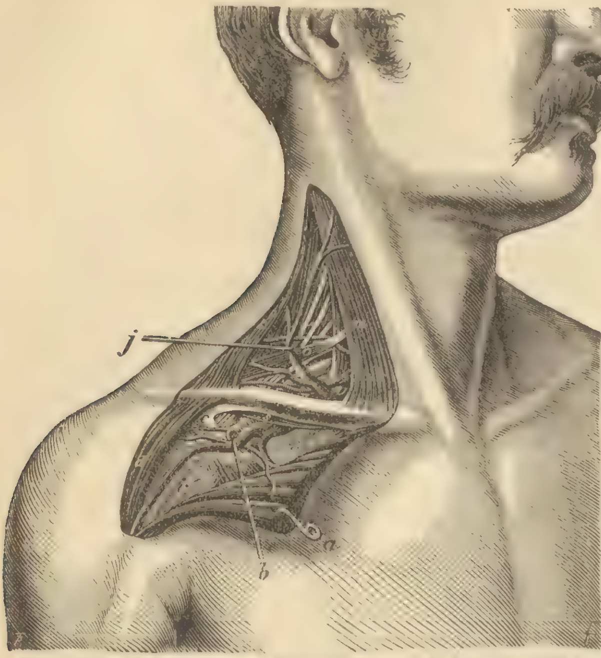
In front of the subclavian artery, in the third region, lie the skin, the superficial fascia, the platysma, the deep fascia, two or three lymphatic glands, the external jugular, supra-scapular, and transverse cervical veins and arteries, the descending filaments of the cervical plexus of nerves, the subclavian muscle, and the clavicle. Behind, the artery rests on the scalenus medius muscle; above and to its outer side are the omo-hyoid muscle and the brachial plexus of nerves. The subclavian vein is immediately behind the clavicle and below the artery.

Immediately external to the insertion of the scalenus anticus muscle, upon a prominent elevation of the first rib, known as its *tubercle*, the subclavian artery passes into the axilla. From this fact arise two practical hints: first, in searching for the vessel, the recognition of this bony prominence by the finger will reveal its position; and, second, from the base of support offered by the rib it is not difficult to control the circulation through the vessels of the upper extremity by pressing with the fingers, or, what is better, with a properly-protected ring of a door-key, thrust down beneath the clavicle. Fig. 423 furnishes an exposure of the principal anatomical components of the subclavian region.

Operation.—*The point of election, or external to the scalenus anticus muscle.*—The proper position in which to place the patient is the recumbent one, with the shoulders moderately elevated, the head extended, and the face turned somewhat to the sound side. Various incisions have been recommended by different surgeons for the exposure of the artery. Roux recommended a vertical incision, the lower extremity of which should rest on the clavicle; Marjolin directed one like an inverted ⊥, the base towards the clavicle; Lisfranc adopted a single incision, parallel with the upper border of the clavicle, and Physick preferred one fashioned like the letter **V**. A slightly curvilinear incision, somewhat straighter than the letter **S**, meets every requirement of the operation. (See line on Fig.

417.) This incision should commence over the external half of the clavicular head of the sterno-cleido-mastoid, half an inch above the clavicle, and be carried parallel with that bone, and conformable to its curves, terminating at the inner edge of the trapezius muscle. Some prefer drawing the skin down over the clavicle and dividing it directly over the bone. It is a convenient way of avoiding the external jugular vein. When the integument is relaxed after this mode of incision, its elasticity will carry the wound to the proper distance above the clavicle. After dividing the skin, the fascia, the platysma, and sometimes a portion of the clavicular origin of the sterno-cleido-mastoid muscle, the external jugular vein, if it be exposed, should be detached by dividing the surrounding threads of connective tissue, and drawing it, with its tributaries, by means of a retractor, in the direction which will remove it farthest out of the way of the operation; this usually is towards the trapezius muscle. If the vein is large, and cannot be disposed of in this manner, and is likely to embarrass the progress of the operation, it should be tied with two ligatures and divided between them. With the director the surgeon now breaks up the loose cellular tissue and the omo-hyoid aponeurosis, tying, if necessary, the transversalis colli artery, which will probably be brought into view. He should now make a careful examination of the wound, in order to locate the vessel. If the scalenus muscle is recognized, the search must be made upon its outer side; if the cords of the brachial plexus or the omo-hyoid muscle are seen, the exploration must be carried farther downwards in the direction of the chest, and more inwards, as the artery lies between the scalenus anticus muscle on the inside and the brachial plexus on the outside. If these landmarks do not serve to convey the required information, let the finger be carried down along the outer side of the wound, under the clavicle, until the first rib is touched, and then, following the latter inwards until the tubercle is reached, feel for the pulsation of the vessel immediately on its outer side. This tubercle, to which so much importance has been attached, is, in my experience, not a very reliable guide, in consequence of its development being often very imperfect. I attach more importance to the tense edge of the scalenus muscle, which can always be distinctly felt down to the first rib, on which it is inserted. The examination at this stage may be considerably simplified by drawing the shoulder downwards, by which the structures at the bottom of the wound will be made much more superficial. The artery having been identified, the

Fig. 423.



Subclavian region exposed. *m*, sterno-cleido-mastoid; *t*, the trapezius muscle; *o*, the omo-hyoid muscle; *j*, hook drawing aside the external jugular vein, which is seen receiving the supra-scapular and transverse cervical veins and emptying into (*v*) the internal jugular vein. By pulling this vein aside, the subclavian artery is exposed as it emerges from beneath the scalenus anticus muscle. Above and to the outer side are the cords of the brachial plexus of nerves.

next step, and a very delicate one, is to effect its denudation without injury to the pleura or to the subclavian vein. Dr. Warren, while isolating this vessel, in a case of unusual perplexity, opened the chest, which was announced by a distinct whistling sound. The accident in this case, however, did not interfere with the patient's recovery. To avoid such complications, the operator should place a finger between the tendon of the anterior scalenus muscle and the vessel, and with the point of the director cautiously tear away the investing cellular tissue from the artery, always keeping the instrument directed towards the rib, so that it may not go beyond the proper limitation. By the sensation imparted to the tip of the finger he will be able to determine when a way has been opened for the thread. The needle bearing the ligature should now be conducted round the vessel from without inwards, directed by the finger stationed at the tubercle, after which, on the removal of the instrument, and its being certain that the thread is properly placed, the vessel may be tied. (Fig. 424.) In my possession is a specimen in which the

Fig. 424.

The subclavian artery exposed and the ligature passed.

phrenic nerve, instead of occupying the usual position in front of the scalenus muscle, passes into the chest over the third part of the subclavian artery. The possibility of such an anomaly will suggest to the surgeon, when tying the vessel at the seat of election, the propriety of examining for this irregularity before securing the thread. Doubtless it was this abnormity which produced the diaphragmatic paralysis that once followed this operation.

Operation in the second part, or beneath the scalenus anticus muscle.—Should it be found imperative to tie the subclavian in this situation, it will be necessary to modify the operation described for the ligation of the vessel external to the scalenus, by making a more extensive division of the clavicular origin of the sterno-cleido-mastoid muscle, and cutting the scalenus anticus partially across. Before dividing the last-named muscle, it should be raised on a director, and only a few fibres should be cut at a time. It will be advisable to leave the inner portion of the muscle undisturbed, as the phrenic nerve is placed in front, and finally to the inner edge, of its fasciculi. The artery having been uncovered, the needle should be passed from above downwards.

Operation within the scalenus anticus.—The successful execution of a ligation of the subclavian in this region, on the right side, involves a degree of bold surgical exactitude which is not possessed by all operators, and on the left side is beset with so many difficulties that nothing short of the direst necessity can justify its attempt. The subclavian artery has been tied within the

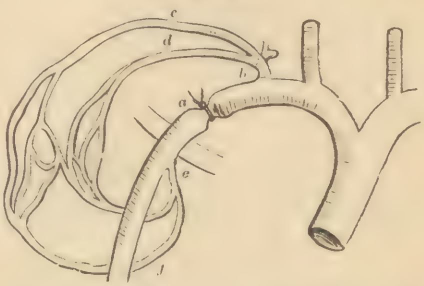
scalenus anticus, or, as it is sometimes termed, "on the tracheal side of the scaleni muscles," fifteen times, in every case with a fatal result. I have arranged these cases in a tabular form.

No.	Surgeon.	Date.	Sex.	Age.	Disease.	Result.	Reference.
1	Colles, left side.	1818.	Male.	33	Aneurism.	Died 9th day, hemorrhage; pleura was wounded in the operation.	Edinburgh Med. and Surg. Journal, vol. xlv. p. 48.
2	Arendt.	1826.	"	......	Aneurism.	Died 5th day, exhaustion.	Dietrich, p. 184. Verm. Abh. von prakt. Aerzte zu St. Peterburg.
3	Boyer.	1829.	"	24	Aneurism.	Died in 24 hours, hemorrhage	Dietrich, p. 31.
4	O'Reilly.	1835.	"	39	Aneurism.	Died 23d day, hemorrhage.	Flood on the Arteries. Powers, p. 69.
5	Hayden.	1835.	Female.	57	Aneurism.	Died 12th day, hemorrhage.	Lancet, vol. i. p. 47, 1837–38.
6	Liston, carotid also tied.	1839.	Male.	32	Aneurism.	Died 36th day, hemorrhage.	Lancet, vol. i. p. 37, 1837–40.
7	Liston, carotid also tied.	....	"	......	Aneurism.	Died 13th day.	
8	Partridge.	1841.	"	38	Aneurism.	Died 4th day, pyæmia. Had pericarditis and pleuritis.	Lancet, vol. ii. p. 603, 1840–41.
9	J. K. Rodgers, left side.	1845.	"	42	Aneurism.	Died 15th day, hemorrhage.	N. York Med. Journal, 1846.
10	Cuvillier, carotid also tied.	....	"	.....	Aneurism.	Died 10th day, hemorrhage.	
11	Mott.	1851.	Female.	21	Aneurism.	Died 19th day, hemorrhage.	American Journal Med. Sci., vol. xii. p. 354, 1833.
12	Auvert.	....	Male.	50	Aneurism.	Died 11th day, hemorrhage.	Selecta Praxis Med.-Chirurg., Tab. lv., lvi., 1848, Paris.
13	Auvert.	....	"	36	Aneurism.	Died 22d day, hemorrhage and pneumonia.	Auvert, op. cit., Tab. lvii. and lviii.
14	Ayres, U. S. V.	1864.	"	......	Shot wounds.	Died in ½ hour, hemorrhage.	Med. Surg. History War of Rebellion, p. 547.
15	Bullen.	1864.	"	21	Shot wounds.	Died in 8 days, hemorrhage.	Med. Surg. History War of Rebellion, p. 547.

In order to expose the vessel within the scalenus on the right side, an incision three inches in length should be carried parallel with the upper border of the clavicle, beginning at the top of the sternum. A second, about the same length, must be made at the inner border of the sterno-mastoid muscle, joining the first at an angle somewhat acute. After dividing the skin, the superficial fascia, and platysma, the surgeon should examine for the anterior jugular, which is often a large vein and is situated at the anterior edge of the sterno-mastoid muscle. If the vessel is present it must be drawn aside, and the deep fascia opened, both in front of the muscle and along the course of the clavicle to the extent of the first incision. Flexing the patient's head, so as to relax the sterno-cleido-mastoid, the surgeon next separates the origins of this muscle by a director and by the finger from the subjacent parts, and then, dividing them across, turns their extremities out of the way. In the cellular tissue underneath will, perhaps, be found the trunk of the anterior jugular vein and one or two muscular branches of the thyroid arteries. Pressing these aside, and dividing the sterno-hyoid and sterno-thyroid muscles, the operator reaches the sheath of the carotid artery and the internal jugular vein, the latter lying in front of the first part of the subclavian. Carefully disengaging the vein from some loose cellular connections, it should be drawn inward, when the subclavian will be exposed, crossed in front by the pneumogastric, cardiac branches of the sympathetic, and phrenic nerves. Displacing these, so as to open a way for the needle, the latter must be carried round the artery from below upwards, so as not to injure the pleura. In bringing the instrument round the posterior surface of the vessel it must be made to follow closely its wall, so that the recurrent laryngeal and sympathetic nerves be not damaged. The thread may be placed between the scalenus muscle and the thyroid axis, or between the vertebral and innominate arteries.

Collateral circulation.—The subclavian inside of the scalenus gives off the vertebral, the internal mammary, and the thyroid axis. When the vessel is ligated in its second or third portion, thus cutting the main channel by which the blood reaches the upper extremity, the vitality of the parts below can be maintained only in the following manner. Two branches are given off by the thyroid axis, which run across the neck in the direction of the shoulder. These are the supra-scapular and transversalis colli arteries. The first reaches the dorsum of the scapula at the coracoid notch, and the second descends along the posterior border of the bone. Coming in the opposite direction, and derived from the axillary, is the subscapular artery, a branch of which—the dorsalis scapulæ—meets and inosculates with the suprascapular branch from the thyroid axis, in the muscles upon the scapula, while the main trunk of the subscapular joins the descending branches of the posterior scapular, which is also derived from the thyroid axis (Fig. 425): thus the loss of the direct channel is supplied.

Fig. 425.



The lines beneath the artery mark the division between the subclavian and the axillary: *a*, ligature on the subclavian at its third part; *b*, thyroid axis; *d*, transversalis colli; *c*, supra-scapular branches; *e*, the subscapular of the axilla; *g*, its dorsalis scapulæ branch, the two inosculating with those of the thyroid axis behind and at the dorsum of the scapula.

The separation of the ligature from the subclavian artery after deligation takes place in most instances between the eleventh and the fifteenth day.

Ligation in the third part of the subclavian has been followed by a very heavy mortality. Of 21 cases* collected by Mr. Poland, in which this part of the vessel was ligated for aneurism, 9 recovered and 12 ended fatally.

Dr. Norris's tables† contain 69 cases of deligation of the subclavian, with 36 recoveries and 33 deaths, a mortality of 47.8 per cent. The operation was done 56 times for aneurism and 9 times for wounds.

Dr. Willard Parker, of New York,‡ has tabulated 196 cases of ligature of the subclavian artery. This collection embraces those contained in Circular No. 5, Surgeon-General's Office, U.S.A., 35 in number, and those reported by Professor Pirogoff in his "Outlines of Military Surgery," 9 in number. Of these ligations, 107 died and 88 recovered, a mortality of 54.5 per cent. In 70 of the cases the vessel was ligated for causes other than aneurism seventy times, 48 of which terminated fatally, a mortality of 68.5 per cent. In 9 instances the second part of the vessel was tied, with 4 deaths, and in 174 cases the third part was ligated, with 89 deaths. Of the persons operated on, so far as noticed, 138 were males and 14 females. The youngest patient was eighteen years old, and the eldest seventy-three years. In 134 instances the side of the body was noticed. Of these, 82 were on the right side and 52 on the left.

Dr. Koch's collection§ embraces 212 cases of subclavian ligation. Of these, 70 were performed for causes other than aneurism, 48 of which died.

Dr. Otis records 52 ligations of the subclavian, with 41 deaths, a mortality of 78.8 per cent.|| These operations were done for shot injuries.

Dr. Morton's table of "Ligations of Large Arteries, performed at the Pennsylvania Hospital,"¶ contains 2 cases of ligature of the subclavian artery for aneurism, with 1 death and 1 recovery.

Though the fatality attending this operation is very great, yet it must not be forgotten that the conditions which require its performance are in

* Guy's Hospital Reports, vol. xv., 1870. † Norris's Contributions to Practical Surgery.
‡ Transactions of the American Medical Association, vol. xviii., 1867.
§ Arch. f. d. Klin. Chirurg., B. x. pp. 195, 280. Berlin, 1869.
|| Medical and Surgical History of the War of the Rebellion, Part I., surg. vol., p. 547.
¶ American Journal of the Medical Sciences, April, 1876.

themselves often necessarily fatal, and that in traumatic cases death is generally the result of the injury, and not of any cause connected with the deligation.

The cause of death in a large majority of instances after ligation of the subclavian artery is hemorrhage.

Complications.—The surgeon may encounter a number of very embarrassing difficulties in his attempts to ligate the subclavian artery. Some of these can be recognized before the operation is begun. Others are discovered only after the parts are exposed.

In large aneurisms there may be such a displacement of the clavicle and the contiguous parts that the vessel is rendered inapproachable.

The tissues around the sac may be so infiltrated and matted together by inflammatory lymph that the safe approach to, and denudation of, the artery become matters of the greatest difficulty.

The sac of an aneurism may involve so much of the artery that no suitable place will be left for the application of a ligature.

The vessel, even when safely reached, may be found so diseased as to forbid the deligation.

The artery may be eccentric in its course, and from this circumstance not easily reached.

In addition to the above may be mentioned the dilatation of veins, enlarged glands, and peculiarities of organization, all of which will prove sources of difficulty to the surgeon in accomplishing his contemplated object.

Ligation of the Vertebral Artery.

The vertebral artery, arising from the subclavian, runs directly upwards, enters the vertebral foramen of the sixth cervical vertebra, passes through similar openings in the vertebræ above, and after reaching the upper surface of the atlas turns backwards around its articular process and enters the cranium through the occipital foramen. This vessel is associated with the internal carotid in supplying the brain with blood.

Surgical anatomy.—The vertebral artery is covered in front by the skin, the superficial fascia, the platysma, the deep fascia, the clavicular origin of the sterno-cleido-mastoid muscle, a second layer of the deep fascia (omo-hyoid), the internal jugular vein, the inferior thyroid artery, and, on the left side, the thoracic duct. Behind it is in relation with cellular tissue and the summit of the pleural sac, having on its outside the thyroid axis, and on its inside the internal jugular vein and the carotid artery, together with the pneumogastric and sympathetic nerves.

On account of wounds, or in consequence of subclavian aneurism, it may become necessary to ligate this vessel. In the only case of successful ligature of the innominate artery, the one reported by Dr. Smyth, the vertebral and the common carotid were both tied. Professor Willard Parker has tied the vertebral, and at the same time the carotid and the subclavian arteries, for the cure of an aneurism of the latter vessel. The vertebral has also been ligated by Maisonneuve, in order to arrest a hemorrhage following a shot wound of the neck. Two other cases of ligation of this artery have been reported by an Italian surgeon.

OPERATION.—In case an external wound existed, situated near to the location of the vessel, the latter might be reached by carefully enlarging the opening; but when such is not the case, the surgeon must make his way to the artery by systematic approaches, either in front of or behind the sterno-cleido-mastoid muscle.

By the first method the incisions will be similar to those employed for tying the innominate artery,—that is, carrying one cut down along the anterior border of the sterno-mastoid to the top of the sternum, and joining it with a second running parallel with the course of the clavicle. After dividing the cutaneous, the muscular, and the fascial layers, the sternal and a portion of

the clavicular region of the sterno-mastoid muscle must be severed. Underneath these will be seen the sterno-hyoid and thyroid muscles. These need not be divided further than to raise their outer edges, and to expose the sheath of the carotid artery and the internal jugular vein. As the latter conceals the vertebral artery, it will only be necessary to draw the sheath with its contents well inwards towards the trachea, when the vessel will be exposed. If any difficulty is experienced in determining its position, a finger should be introduced into the bottom of the wound, and search made for the tubercle at the extremity of the transverse process of the sixth cervical vertebra. At the root of this process the artery enters its first foramen, and immediately below this its pulsation should be discovered. After its careful isolation, the thread must be passed from within outwards, in order that the internal jugular vein be not harmed.

By the second method the vertebral is reached by the same incisions as are used to expose the subclavian on the tracheal side of the scaleni muscles. If this plan be adopted it will not be necessary to divide more than the clavicular head of the sterno-cleido-mastoid muscle. Due care must also be practiced not to injure the phrenic nerve while approaching the artery in question.

Ligation of the Inferior Thyroid Artery.

Except in case of hemorrhage, the result of a wound of the neck, the surgeon will rarely feel it his duty to ligate the inferior thyroid artery. Both vessels have been tied in hypertrophic conditions of the thyroid glands, but with such indifferent success that the practice is not worthy of repetition. The vessel is a branch of the thyroid axis, and reaches the thyroid body by passing beneath the sheath of the carotid and internal jugular. If from any circumstance it is deemed necessary to resort to ligation of the inferior thyroid, the simplest manner of reaching the artery will be to proceed as for the ligation of the primitive carotid, namely, by making an incision along the inner edge of the sterno-cleido-mastoid muscle, commencing opposite the thyroid cartilage, and prolonging the incision downwards towards the sternum to the extent of two and a half inches. On reaching the sheath of the common carotid, the operator next looks for a branch of the inferior thyroid passing to the thyroid body from beneath the sheath, and if one is discovered, it will only be necessary to trace it back until the trunk of the artery is reached in the fissure between the great vessels and the œsophagus, where it should be tied.

Ligation of the Internal Mammary Artery.

The internal mammary artery is a branch from the first part of the subclavian, which, after its origin, passes downwards beneath the clavicle, and descends along the inner surface of the anterior walls of the chest external to the pleura, accompanied with its satellite veins, and resting upon the costal cartilages a little external to the margin of the sternum. At the sixth intercostal space the vessel divides into the musculo-phrenic and superior epigastric branches.

Wounds of the internal mammary are not uncommon on the battle-field. It is probable that many perish in this way without the lesion being detected. When after a shot or other injury along the margin of the sternum the signs of internal hemorrhage appear, without any evidence of the lung being implicated, a wound of the internal mammary may be reasonably inferred.

Five cases were reported during the War of the Rebellion. In two the artery was tied, and in the other three an attempt was made (I suppose, after the manner of Larrey) to control the bleeding by plugging the wound. None of the patients survived the injury.

Notwithstanding the fact that the internal mammary lies within the bony and cartilaginous walls of the anterior parietes of the chest, for the first three

intercostal spaces its ligation is not a task of great difficulty, unless, in consequence of comminution of the cartilages of the ribs or of the sternum, and the resulting extravasation of blood or of inflammatory products, the parts have become changed in their normal relations.

Operation.—Make a vertical incision, commencing at the lower border of the clavicle, two inches and a half in length, parallel with and three lines external to the margin of the sternum. Divide consecutively the skin, the superficial fascia, the fibres of the pectoral muscle, the external intercostal aponeurosis, and the muscular fibres of the internal intercostal. The last structure can be best opened by raising and dividing the fasciculi on the bent extremity of a director. The last shreds of tissue should be scratched through with the instrument, when the artery, with its accompanying veins, will be exposed. The last step of the operation consists in isolating the vessel and encircling it with a ligature.

Deligation of the internal mammary below the third or at most the fourth intercostal space is scarcely feasible, on account of the close proximity of the cartilages; and if under any emergency the surgeon is compelled to tie the vessel at a point so low down, it will be best to cut out one of the costal cartilages with a pair of bone forceps, thus throwing two intercostal spaces into one, by which procedure ample room will be obtained for the object in view.

Ligation of the Axillary Artery.

Surgical anatomy.—The axilla is a conical space situated between the upper part of the chest and the arm. The apex of the cone answers to a point between the upper border of the scapula, the clavicle, and the first rib. When the arm is brought close to the side, the axilla becomes a mere fissure; but it presents an extensive concavity when the arm is drawn off from the body, bounded in front and behind by muscular folds, the first formed by the pectoralis major muscle, and the last by the latissimus dorsi and the teres major.

Fig. 426.

The great pectoral and deltoid muscles exposed, exhibiting the fissures between the clavicular and the sternal portion of the first; also the depression between the pectoral and the deltoid, in which lie the cephalic vein and a branch of the thoracica acromialis. The fascia turned down.

When the arm is carried off from the side, two fissures can, in most instances, be discovered on the surface of the chest. One, commencing at the sterno-clavicular articulation, can be traced to the arm, ending half an inch above the anterior margin of the axilla. This fissure marks the division between the clavicular and the sternal portion of the pectoralis major muscle, the chief significance of which is that when opened it leads down to the first portion of the axillary artery. The second fissure begins at a triangular depression below the middle of the clavicle, and ex-

tends downwards and outwards. This fissure is the cellular interspace which exists between the clavicular fibres of the pectoralis major muscle on the inside and the deltoid muscle on the outside. In this narrow depression lie the cephalic vein, and a small branch from the thoracic acromial artery. (Fig. 426.) When the skin and the superficial fascia are turned aside from the pectoralis major muscle, and the sheath of the latter is raised from the clavicle downwards to the fold of the axilla, or to the lower border of the muscle, the membrane will be found to divide into two lamellæ, one passing up between the pectoralis major and pectoralis minor muscles (*interpectoral fascia*), and becoming attached to the costo-coracoid aponeurosis which lies in front of the subclavian muscle. (Fig. 427.) The other, and deepest

Fig. 427.

Pectoralis major turned aside, showing the interpectoral fascia passing over and beneath the pectoralis minor muscle.

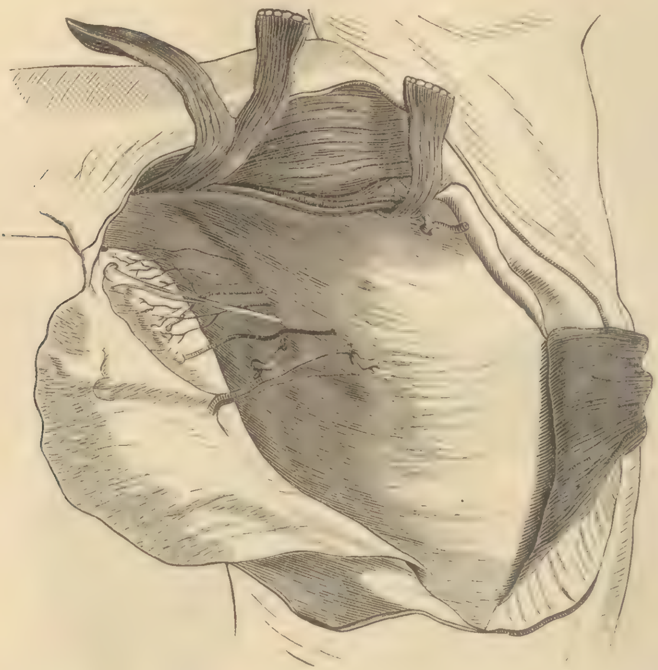
layer, passing beneath the pectoralis minor muscle, is the true *axillary fascia*, and is continuous with the sheath of the axillary blood-vessels and nerves up into the neck. (Fig. 428.) When this deep leaf of the fascia is opened, a number of lymphatic glands, fat, connective tissue, arteries, veins, and nerves will be exposed.

When the pectoralis major muscle is detached from its clavicular origin and reflected inwards and downwards, the pectoralis minor will be seen inserted by its tendon upon the coracoid process of the scapula. In front of the pectoralis minor runs the cephalic vein, which empties into the axillary vein immediately below the clavicle (Fig. 428), and beneath the muscle pass the axillary artery, the axillary vein, and the brachial plexus of nerves. The pectoralis minor muscle divides the axillary vessels into three surgical regions,—the first above the upper border of the muscle, the second beneath the muscle, and the third from its lower margin to the insertion of the latissimus dorsi and teres major muscles. The first and third regions only are those of surgical importance.

In the first region, that part between the subclavian muscle and the pectoralis minor, the axillary artery is covered by the skin, the superficial fascia, the pectoralis major muscle, and the two layers of the pectoral fascia, having the axillary vein on the inside and the axillary plexus of nerves on

the outside. It is in this region that the cephalic enters the axillary vein. (Fig. 429.)

Fig. 428.



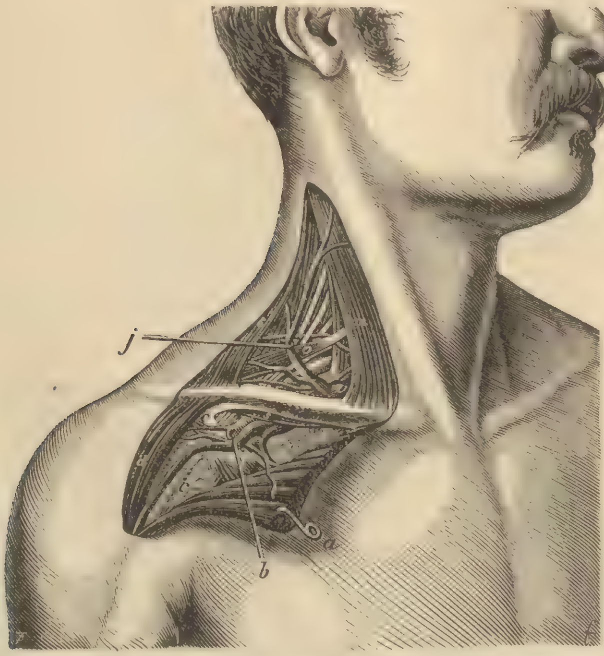
Pectoralis divided and turned aside, showing the deep pectoral or true axillary fascia. The cephalic vein is seen passing through the fascia to enter the axillary vein. Numerous nerve-twigs are also represented perforating the fascia.

Operation.—The patient should be placed upon the back, having the shoulders somewhat raised, and the flexed arm carried a little off from the body. There are two modes of uncovering the vessel, one by a linear incision, opening the fissure between the clavicular and sternal portions of the pectoralis major muscle, and the other by a rectangular incision, one limb of the cut corresponding to the fissure between the deltoid and clavicular portions of the pectoralis major muscle, and the other corresponding to the course of the clavicle but a little below it. (See Fig. 417.) By either route the vessel can be reached without much difficulty. For one who is not entirely familiar with anatomical details the last method will be the preferable one. The first plan has the advantage of not cutting any muscular fibres, but also the disadvantage of hampering somewhat the manipulation requisite to the isolation of the artery. I shall describe both approaches to the vessel.

First. Make a vertical incision three inches long, commencing at the clavicle, in the middle of the triangular space between the deltoid and pectoralis major muscles. A second cut is next made, commencing at the first, one inch below the clavicle, and prolonged inwards three inches, running parallel with the clavicle. These preliminary incisions should not extend deeper than the skin. The necessity for executing the last one an inch below the collar-bone arises from the tendency of the platysma to draw up the integument when the latter is divided. The superficial fascia should next be raised on the director and incised, it being borne in mind in doing this that the cephalic vein and the descending branch of the thoracic acromial artery lie immediately underneath, in the fissure between the deltoid and pectoral muscles. The cephalic vein being exposed, and the thin layer of

fascia which covers it being divided close along the edge of the clavicular part of the pectoral muscle, the finger or a director will suffice to separate the

FIG. 429.



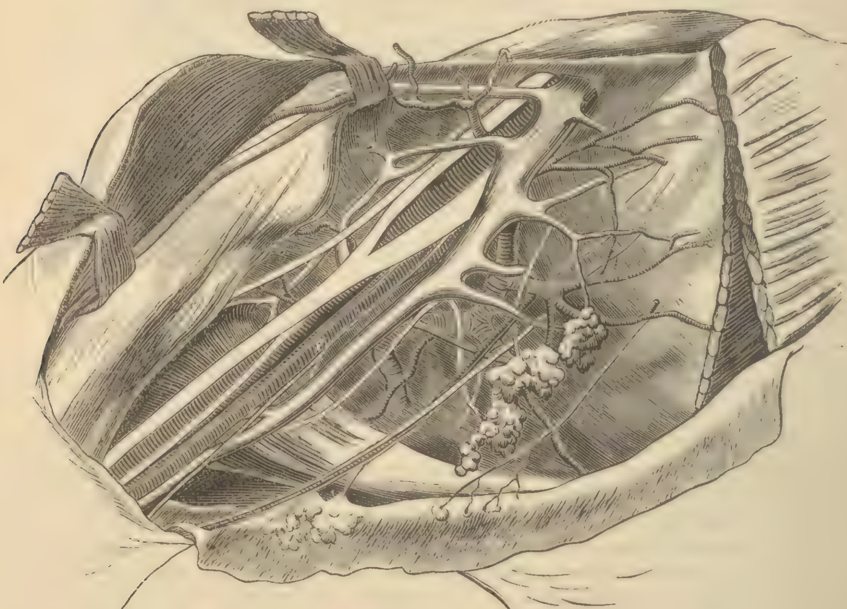
Surgical relations of the axillary artery above the pectoralis minor muscle: *a*, clavicular part of the pectoralis major detached and turned down; *b*, the cephalic vein drawn aside by a hook, above which it enters the axillary vein, and beneath which are seen the axillary artery and, farther out, the axillary plexus of nerves; *c*, the coracoid process, to which is attached the pectoralis minor; *d*, the deltoid muscle; *e*, the coraco-clavicular aponeurosis.

latter from both the vein and the deltoid. After dividing the platysma, the operator next commences the detachment of the fibres of the pectoral muscle from the clavicle, cutting close to the bone by short, light, and repeated strokes, completing the division of the deepest fibres upon the director; after which the muscle may be turned downwards and inwards. In doing this the thoracica acromialis and superior thoracic arteries will be exposed, and, very probably, will demand ligation. The interpectoral and the axillary fascia, together with some loose cellular tissue, being now broken up, the next step is to identify the axillary artery. In doing this the finger should be introduced into the wound, and made to touch the upper border of the pectoralis minor muscle below and the clavicle above. These points being ascertained, the upper and lower limits of the vessel have been determined, and between them the search is to be conducted. If now a careful inspection of the bottom of the wound is made, the axillary vein will be seen, corresponding to the middle of the clavicle. If any doubt remains, the vessel may be pressed with the finger close to the subclavian muscle, beneath which it appears, when, if it is the vein, its thin walls will become distended by the impediment offered to the passage of the blood. The vein having been discovered, the surgeon has gained his second landmark. He knows that the axillary artery is on its outer or humeral side, and the search is next made in that direction. Perhaps he passes unnecessarily far out and encounters the cords of the axillary plexus of nerves; in these he has a third landmark, the artery being on their inner side: so that the vessel must be found between the vein and the

nerves. In addition to these referential points, the pulsation of the artery may be felt, which will serve still further to dispel any doubt that may remain as to its position. In effecting the ligation of the artery, the work of denudation should begin on the side next to the vein, and when the two have been separated the point of a finger should be interposed while the posterior and outer surfaces of the vessel are being isolated. An assistant should also draw the cephalic vein outwards and upwards, and if the external jugular communicates with the former over the clavicle, it may be necessary, in order to pull the cephalic sufficiently far out of the way of danger, to tie the communicating branch with two threads and sever the vein between them. The artery having been detached from all its surrounding connections, the needle bearing the thread must be passed from within outwards above the thoracica acromialis and superior thoracic branches, its point being received on the end of the finger as it appears between the vessel and the axillary plexus of nerves.

Second. The arm being drawn off from the side in order to render apparent the fissure between the two portions of the pectoralis major muscle, an oblique

Fig. 430.



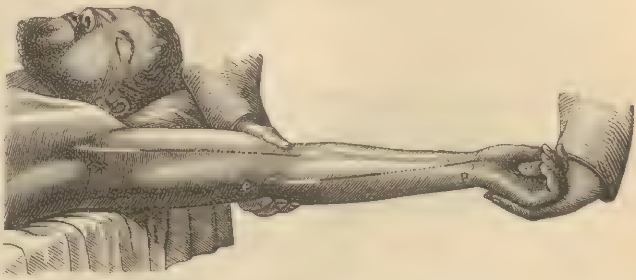
Axillary artery, vein, and nerves exposed; also the first portion of the brachial artery. High origin of the radial artery also seen.

incision is made over this depression, three inches in length, commencing half an inch from the sterno-clavicular articulation. The skin and fascia being divided, the muscular interspace must be opened, and its sides separated with the director and the fingers. In doing this it must be remembered that the course of this fissure is upwards towards the clavicle. If the attempt is made to enlarge the opening directly backwards, the artery will never be found. As the separation of the two portions of the pectoral progresses, the arm should be brought towards the side of the body, in order to relax the muscle and to allow of a free exposure of the deeper parts. The space between the clavicle and the pectoralis minor being reached, the subsequent steps of the deligation are the same as in the first method, already described.

Surgical anatomy of the third region of the axillary artery.—This includes a description of that portion of the axillary between the lower border of the

pectoralis minor muscle and the insertion of the latissimus dorsi and teres major muscles. The vessel is covered in front by the skin, the superficial fascia, the pectoralis major muscle, and the axillary fascia. Behind are situated the subscapularis, the tendons of the latissimus dorsi and teres major muscles, and the musculo-spiral and circumflex nerves. On the outer side lie the coraco-brachialis muscle, and the median and musculo-cutaneous nerves; on the inner side are the ulnar and internal cutaneous nerves, and the axillary vein. The branches given off by the axillary artery are the thoracica acromialis, the thoracica superioris, the thoracica longa, the thoracica alaris, the subscapularis, and the anterior and the posterior circumflex. (Fig. 430.)

FIG. 431.



The anterior and posterior folds of the axilla, and the biceps muscle: immediately under the anterior fold and the bicipital swell is a white line giving the course of the axillary artery.

Once in about thirty-five times the radial artery, and much less frequently the ulnar, is given off from the axillary,—an irregularity which should not be lost sight of in cases of ligation in this part of the vessel, as the one trunk might readily be mistaken for the other.

OPERATION.—The patient being placed in the recumbent position and the arm drawn off from the side, a line may be extended, if desired, from the junction of the anterior and the middle third of the axilla to the middle of the bend of the arm. (See Fig. 431.) The upper extremity of this line will be found to indicate the position and course of the axillary vessels. When the arm is carried off at right angles with the body, the anterior and posterior muscular folds of the axilla become strongly prominent. Emerging from beneath the anterior folds will be seen the biceps flexor cubiti muscle, and immediately within this a second ridge or swell, which is the coraco-brachialis. (Fig. 432.) The axillary artery lies along the inner edge of the latter. Placing a finger in the summit of the axilla, at the upper extremity of this line, while the arm is still abducted, commence at this point an incision (Fig. 432), which should be prolonged downwards along the inner edge of the coraco-brachial ridge for two inches. After dividing in succession the skin, the superficial fascia, and the deep fascia (the latter upon the director), muscular fibres of the coraco-brachial will be exposed, and search must now be made for the vessel, the parts being held asunder by a retractor and the finger. (Fig. 433.) The arm being brought a little nearer to the side, the director alone should be used to lacerate any shreds of connective tissue which may obscure the parts. To discover

FIG. 432.

Limb drawn away from the body, and the index finger of one hand of the surgeon fixing the integument at the summit of the axilla, while with the other hand he is about to commence the incision for the ligation of the third part of the axillary artery.

the artery, should it not be readily recognized by its pulsation, the operator must commence at the coraco-brachialis muscle and work his way inwards. First will be seen the median nerve, next the musculo-cutaneous nerve perforating the muscle, and then the axillary artery, on the inner side of which lies the axillary vein. After the vessel has been isolated, the needle should be passed between the artery and the vein, and its point conducted safely round by making counter-pressure with the finger on the outer side, at the same time crowding the median and musculo-cutaneous nerves towards the coraco-brachialis muscle.

FIG. 433.

Ligation of the axillary. The sides of the wound held apart by a retractor and the thumb.

The ligation of the axillary artery dates back only to the year 1815, when it was first tied by Chamberlaine, of Jamaica.

In all cases of ligation where the choice lies between the first part of the axillary and the third part of the subclavian artery, the latter should be unhesitatingly adopted, as both the easier and the safer operation.

Ligation of the Brachial Artery.

Surgical anatomy.—The brachial artery extends from the tendon of the teres major muscle, along the inner and anterior portions of the arm, to about three-quarters of an inch below the bend of the elbow-joint, at which point it divides into the radial and ulnar arteries. The vessel is quite superficial in its entire course. It is placed along the inner edge of the coraco-brachialis and biceps flexor cubiti muscles, and in a groove between these and the triceps extensor cubiti posteriorly. The exact relations of the vessel may be considered in three different positions:

1. *Upper third.*—This includes a portion of the vessel equal in extent to the humeral portion of the coraco-brachialis muscle, and therefore partly in the axillary space. In this division the brachial artery is covered by the skin, the superficial fascia, and the bicipital fascia. Behind lie the triceps, and the musculo-spiral nerve. On the outer side are the coraco-brachialis muscle and the median nerve, and on the inner side are the basilic vein, and the internal cutaneous and ulnar nerves. (See Fig. 430.)

2. *Middle third.*—This part of the artery lies along the inner border of the biceps muscle, and is crossed by the median nerve.

3. *Lower third.*—The vessel is situated on the inner margin of the biceps muscle and its tendon, and is covered, in addition to the skin and fascia, by the bicipital aponeurosis. The median nerve lies a short distance to its inner side, and both nerve and artery rest upon the brachialis anticus muscle. (See Fig. 436.) The brachial artery in front of the bend of the arm is invested with additional interest on account of its relation to the cutaneous veins, especially the median basilic, which lies directly over the vessel and is separated from it only by the bicipital aponeurosis. This vein is generally more prominent than any other at this part of the arm, and on this account has always offered an attractive mark for the lance of the

phlebotomist, by which means the artery has often been wounded, giving rise to arterio-venous aneurism.

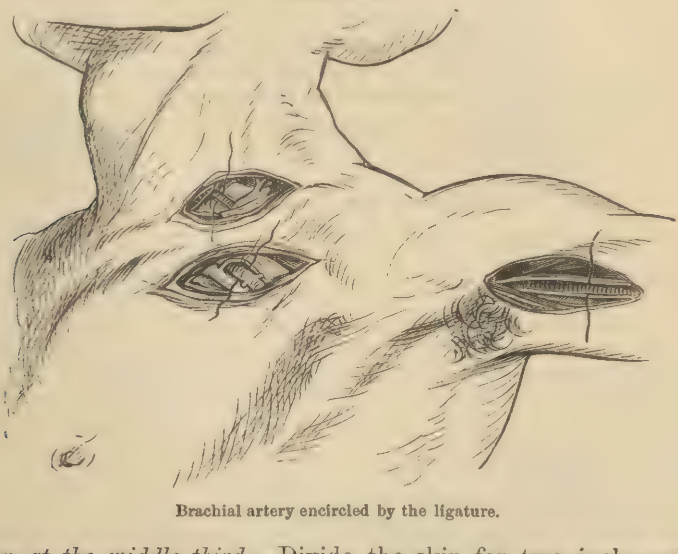
There is also in front of the articulation at the bend of the arm a deep fossa,—the anticubital,—the sides of which are formed by the pronator radii teres and supinator muscles, and the floor by the brachialis anticus muscle. In this fossa are the brachial, radial, and ulnar arteries, together with the median nerve and a large communicating vein. Hence the danger attending penetrating wounds within the limits of this region.

The branches distributed by the brachial artery are the superior profunda, the inferior profunda, the anastomotic, and the muscular.

Operation.—A line extended from the summit of the axilla to the middle of the antibrachial fossa indicates the entire course of the brachial artery. (See Fig. 431.)

Ligation at the upper third.—Place the patient in the recumbent position, and draw the arm off from the trunk. Feel for the muscular ridge of the coraco-brachialis just within that of the biceps muscle, and along its inner border make an incision two inches in length, holding the knife at right angles to the surface of the arm. After dividing the skin, the remaining layers of fascia should be raised upon the director and incised, when, after lacerating its sheath, the artery will be exposed, or can readily be detected by its pulsation. If from any cause the latter is not distinguishable, the artery may be identified by recalling the fact that there is nothing interposed between it and the coraco-brachialis muscle except the median nerve, and that the basilic vein lies close along the inner side. After the denudation of the artery the needle must be passed from within outwards, so as to inflict no injury on the vein, at the same time all necessary precautions being used not to include the median nerve in the ligature. (Fig. 434.)

Fig. 434.



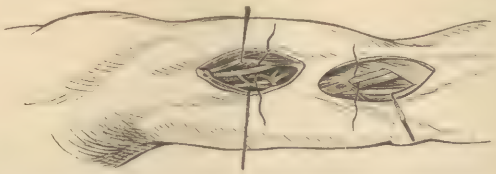
Brachial artery encircled by the ligature.

Ligation at the middle third.—Divide the skin for two inches along the inner border of the middle of the biceps muscle. Raise and incise the superficial fascia with its fat on the director, and then open the fibrous membrane which covers the biceps muscle, taking care not to wound the median nerve which crosses over the artery to the inner side of the arm. By lacerating the cellular tissue along the edge of the muscle the artery will be exposed, accompanied by its venæ comites. The ligature may be passed in either direction. (Fig. 435.)

Ligation at the lower third.—The surgeon should alternately flex and extend

the arm until the tendon of the biceps muscle is distinctly recognized, along the inner edge of which an incision two inches long should be made, dividing successively the skin, the superficial fascia, and the bicipital aponeurosis,

FIG. 435.



Ligation of the brachial artery at the middle and lower thirds.

immediately under which will be found the artery, the median nerve being some distance to its inner side. (Fig. 435.)

Ligation of the brachial artery may be required on account of hemorrhage or aneurism, and at no point is the operation a difficult one.

The occasional irregularities in the origin of the radial, and in some instances of the ulnar artery, should not be forgotten in ligations of the brachial, as when such abnormities exist the vessels generally lie side by side, in which case the proper one for the ligation could only be selected by alternately making compression on both, and thus learning which commands the circulation in an aneurism or the hemorrhage in case of a wound.

Collateral circulation.—The vessels which maintain the circulation of the arm after ligation of the first part of the brachial artery are the circumflex and subscapular arteries from the axillary, with the ascending branches of the superior profunda artery. Where the ligature is applied at the middle or lower third of the brachial artery, the superior and the inferior profunda (and if near the elbow the anastomotica magna) communicate with the recurrent branches of the radial, the ulnar, and the interosseous. (See Fig. 443.) These compensating vessels of the arm are neither large nor numerous, nor are the communications between those of the arm and those of the forearm very free: so that the risk of gangrene after ligation of the artery is very great.

Ligation of the Radial Artery.

Surgical anatomy.—The radial is the more superficial artery of the two given off by the brachial. It leaves the latter vessel at the middle of the bend of the arm, and passes obliquely downwards and outwards to the wrist, where it runs beneath the inner extensor tendons of the thumb to the lower end of the radius, and enters the hollow at the root of the thumb by passing beneath the two inner extensor pollicis tendons, finally reaching the palm of the hand between the two heads of the first interosseous muscle.

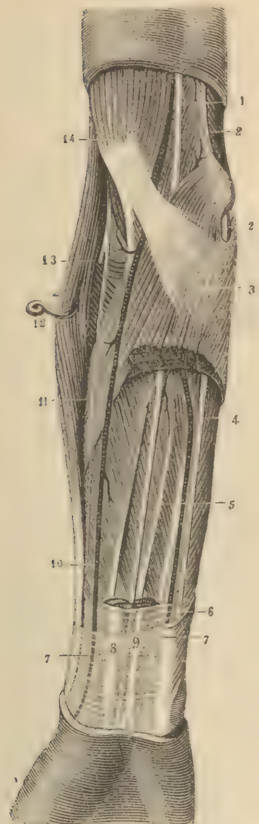
In the arm the radial artery, at its upper third, lies between the pronator radii teres muscle on the inside and the supinator radii longus on the outside. The remaining portion of the artery is placed between the flexor carpi radialis on the inside and the supinator radii longus on the outside. The radial nerve, which at the upper third of the arm lies some distance to the outside of the vessel, at the middle third approaches it very closely, though still occupying the radial side of the artery, while at the last third it becomes again far removed from the vessel, by passing underneath the tendon of the supinator longus muscle to the back of the hand. (See Fig. 436.) The vessel lies immediately under the skin, the superficial fascia, and the deep fascia.

OPERATION.—A line extended from the middle of the bend of the arm to a point midway between the styloid process of the radius and the tendon of the flexor carpi radialis marks the course of the vessel. (Fig. 437.) The

artery may be tied at any part of the arm. I shall describe its ligation at the upper and at the lower third.

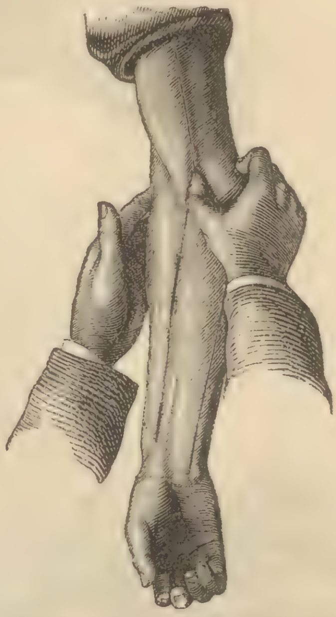
Ligation in the upper third.—In the direction of the line already described make an incision two inches in length, commencing one inch below the bend of the elbow. (Fig. 438.) After dividing the skin and exposing the celluloadipose tissue, look for the median vein, and incise the fascia in such a manner as to avoid the vessel. The deep fascia having been exposed, look for the yellow line which separates the supinator muscle on the outside from the pronator radii teres on the inside. If this cannot be recognized, the interspace may be discovered by the finger, after which, the fascia being opened, the artery will be found surrounded by adipose tissue, and upon being separated from its accompanying veins may be raised on the needle. (See Fig. 441.) The nerve lies so far external to the artery, beneath the supinator radii longus muscle, that it should not be seen in the operation, unless the surgeon cuts very wide

FIG. 436.



Arteries of the lower part of the arm and of the forearm and their relations. 1, median nerve, external to which, close along the edge of the biceps, 14, lies the brachial artery; 2, ulnar nerve, passing from the arm to the forearm, between the internal condyle of the humerus and the olecranon process of the ulna; 4, ulnar artery, approaching the ulnar nerve; 5, median nerve, exposed by cutting away a portion of the flexor sublimis digitorum and the flexor carpi ulnaris muscle; 6, deep fascia; 7, deep fascia covering the radial artery; 8, tendon of the flexor carpi ulnaris; 9, palmaris longus; 10, radial artery, passing over the tendon of the pronator radii teres, and resting lower down on the flexor longus pollicis, with the radial nerve, 11, on its outer side; 12, supinator longus drawn aside by hook.

FIG. 437.



Lines showing the course of the radial and ulnar arteries.

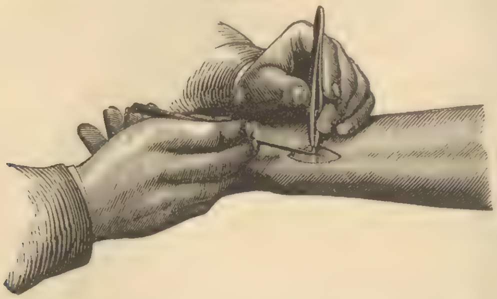
FIG. 438.

Making the incision for the ligation of the radial artery at its upper third.

of the mark. In the event of its being exposed, it would serve as a landmark, instructing the operator to carry his search more towards the ulnar side of the arm.

Ligation in the lower third.—By strongly extending the hand, the tendon of the flexor carpi radialis, which is the first tendon on the inside of the radius, may be seen or felt. On the radial side of the tendon make an incision one inch and a half long, beginning one inch above the wrist-joint. (See Fig. 439.) The artery is very superficial, and the incision should be made with a

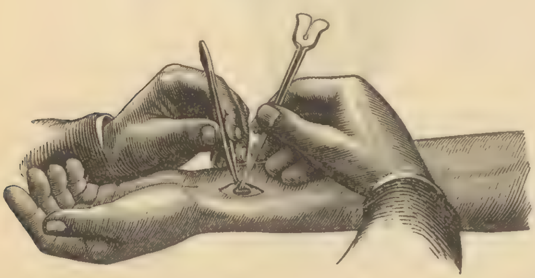
FIG. 439.



L'gation of the radial at its lower third. Opening the deep fascia.

light hand. After dividing the skin, and the superficial and deep fasciæ (Figs. 439 and 440), the last two being previously raised on the director, the artery, with its satellite veins, will be discovered between the flexor carpi radialis and supinator radii longus muscles. The needle may be passed in either direction, as the radial nerve leaves the vessel about the middle of the forearm. (Fig. 441.)

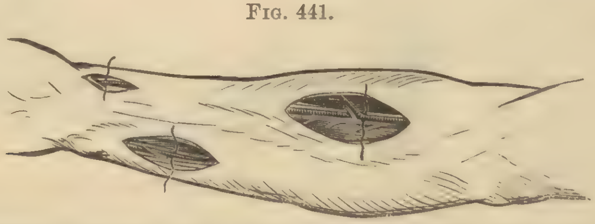
FIG. 440.



Ligation of the radial at its lower third. Isolating the artery.

Ligation of the radial artery at the root of the thumb.—Between the lower end of the radius and the root of the thumb is a deep fossa, which is bounded on the inside by the tendons of the extensor ossis metacarpi pollicis and the extensor primi internodii pollicis, and on the outside by the tendon of the extensor secundi internodii pollicis. If the skin, the superficial fascia, and a thin membranous layer be turned aside, the artery

FIG. 441.

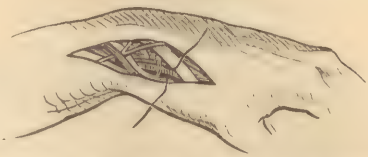


Ligation of the radial and ulnar arteries. Ligature passed at the upper and the lower third of the radial, and at the lower third of the ulnar.

will be found lying in the midst of some fatty tissue and resting upon the lateral radio-carpal ligament.

OPERATION.—An incision one inch and a half long should be made obliquely across the fossa, observing to avoid one of the chief radicles of the radial vein, which lies immediately in the course of the wound, and in the superficial fascia. After opening the latter and the deep fascia, and displacing some loose adipose tissue, the artery will be reached at the bottom of the depression between the tendons of the thumb. The operator must not injure the sheath which envelops these tendons, as such an accident might be followed by a troublesome and diffuse inflammation. (Fig. 442.)

FIG. 442.



Ligation of the radial at the root of the thumb.

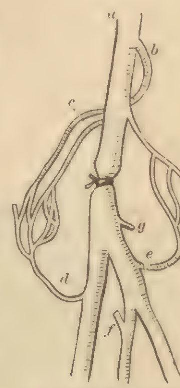
Ligation of the Ulnar Artery.

Surgical anatomy.—The ulnar leaves the brachial artery in the fossa at the bend of the arm, and, passing underneath the superficial flexor muscles which arise from the internal condyle, descends along the inner side of the arm, between the flexor carpi ulnaris muscle on the inside and the flexor sublimis digitorum muscle on the outside. The vessel rests upon the flexor profundus digitorum muscle, has the ulnar nerve to its inner side, and is crossed at the lower third of the arm by the skin, the superficial fascia, and the deep fascia. (See Fig. 436.)

The deligation of the ulnar artery is limited to the lower third of the arm, in consequence of the great mass of muscular tissue which overlies the vessel above this part.

OPERATION.—The course of the ulnar artery is indicated by a line extended between the radial border of the pisiform bone and a point at the junction of the upper and the middle third of the forearm, and three-quarters of an inch external to its ulnar border. (See Fig. 437.)

FIG. 443.



Anastomosis between the radial and ulnar recurrent arteries, *d* and *e*, and the superior and inferior profunda arteries from the brachial, *b* and *c*.

If the hand be forcibly extended, there will be seen above the wrist a prominent fleshy swell, to the inner side of the tendon of the palmaris longus. This is the flexor sublimis digitorum muscle. Along the inner or ulnar side of this swell is a depression, and it is in this groove that the ulnar artery lies.

Make an incision one inch and a half long above the wrist, in the depression between the flexor carpi ulnaris and the flexor sublimis digitorum, which depression is immediately in line with the pisiform bone. Let the superficial fascia be incised, and then, flexing the hand so as to relax the deep fascia, raise the latter with the forceps, and, after cautiously nicking it, introduce the director and slit it up freely.

If now the tendon of the flexor carpi ulnaris be turned a little inwards, the artery will be found with the ulnar nerve close along its inner side. From the nerve and its accompanying veins the vessel must be separated, and the needle passed from within outwards. (See Fig. 441.)

The radial and ulnar arteries may demand ligation on account of traumatic aneurism, or for wounds, such as are frequently inflicted by glass, chisels, and knives. Wounds of the palmar arch demand ligation at the seat of injury, and have been considered under the head of injuries of the upper extremity.

Collateral circulation.—The radial artery shortly after its origin gives off a branch,—the radial recurrent,—which turns upwards along the outer side of the joint. The ulnar artery, in like manner, furnishes the ulnar recurrent, and in addition the interosseous trunk. Both recurrent vessels give off de-

scending branches, which communicate with muscular branches given off by both of the main arteries lower down. It is these inosculations, together with the interosseous, which maintain the circulation below, when the radial or the ulnar is tied.

Ligation of the External Iliac Artery.

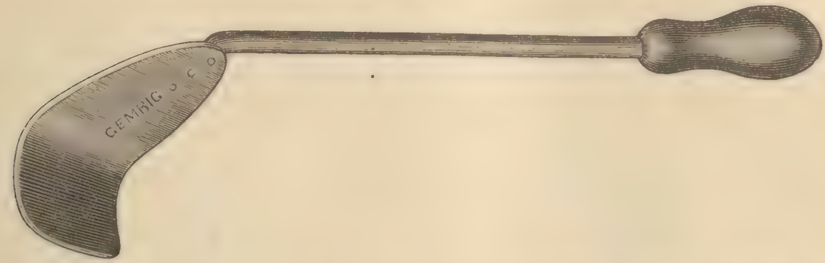
Surgical anatomy.—The external iliac artery, the most superficial of the two branches of the common iliac, extends from the sacro-iliac juncture along the inner margin of the psoas magnus muscle to the middle of the crural arch, where it becomes the femoral artery.

In front are situated the peritoneal sac containing the intestines, the spermatic vessels, and the genito-crural nerve. On the outside lies the psoas magnus, to which the artery is attached by a fold of the iliac fascia; above, the external iliac vein is situated behind, and below it is to the inner side of the vessel. (See Fig. 445.)

Operation.—The lower bowel having been previously emptied by an enema, and the patient placed upon the back, an incision should be made parallel with Poupart's ligament, commencing one inch above the anterior superior spinous process of the ilium, and terminating a little external to the external abdominal ring. (See Fig. 445.) The incision should be slightly curvilinear, having the convexity downwards. The skin and superficial fascia being divided by successive touches of the knife, and one or two branches belonging to the superficial epigastric and circumflex ilii arteries having been tied, the tendon of the external oblique muscle should be raised upon the director and incised to the full extent of the external wound. Succeeding these layers come the internal oblique and transversalis muscles, which in turn must be divided in a similar manner, but with increasing caution as the fibres of the last are severed. At this stage of the operation it will be necessary to tie some branches of the circumflex ilii artery. Beneath the transversalis muscle lies the transversalis fascia, which serves to connect the latter with the peritoneum. And now begins the most delicate part of the task, namely, the breaking up of this fascia and the detachment of the sac of the peritoneum from Poupart's ligament and the iliac fossa. This is best effected by a pair of forceps and the fingers, and should commence nearer to the external than to the internal extremity of the wound, as there the serous membrane is most loosely connected to the subjacent parts. Let the operator commence by picking up some of the fleecy fibres of the transversalis fascia with the forceps, and with a finger of the opposite hand make counter-pressure on the peritoneum. A portion will be found to yield, when the process may be repeated, until an opening has been made sufficiently large for the introduction of the fingers, by which the remaining separation, necessary for the exposure of the artery, can most conveniently be accomplished. Too much delicacy cannot be observed in detaching the peritoneum from the iliac fossa. It is very unfortunate when, either in consequence of strong inflammatory adhesions or from maladroit manipulation, this membrane is torn. The intestines are liable to escape through the opening, and the danger of a fatal peritonitis becomes imminent. After pushing up the serous sac and passing a finger into the opening, the external iliac artery will be detected by its pulsation, having the anterior crural nerve a short distance to its outer side and the external iliac vein on its inner side as the artery approaches the crural arch, but behind at the upper half of the vessel. A broad retractor (Fig. 444) may now be slipped along the upper wall of the wound, and the parts held out of the way by an assistant, while the surgeon carefully isolates the vessel from its surrounding connections, and, passing the needle from within outwards between the vein and the artery, brings it round to the outer side of the latter, where it should be received on the extremity of the finger and conducted safely through. After the completion of the operation the margins of the wound should be drawn together by a number of

interrupted sutures, extending through all the strata of tissues down to the peritoneum; and, in order to relieve the stitches from tension, the patient should be placed in bed, with the thigh flexed and the shoulders elevated.

FIG. 444.



Author's retractor for holding aside the sac of the peritoneum during operation upon the iliac arteries.

The ligation of the external iliac artery was first performed in 1796, by Mr. Abernethy. The incision which this surgeon adopted was in the direction of the course of the artery. He commenced above Poupart's ligament, half an inch outside of the external ring, and terminated his cut three inches above and in the direction of the median line. The incision recommended by Sir Charles Bell for opening the walls of the abdomen in order to ligate the external iliac artery corresponds in all particulars to the one which I have detailed. Scarpa's method differs from others in that the division of the parietes begins below and in front of the anterior superior spinous process of the ilium. Sir Astley Cooper made a semi-elliptical cut, convex downwards, of which one of the extremities rested a short distance above the iliac spinous process, and the other at the inner side of the external ring. Many others have been described, for example, those of Bogros, Lisfranc, Rust, Langenbeck, and Delpech; but they all, except in some very unimportant particulars, closely resemble one another. The operation of tying the external iliac artery was first executed in this country by Dr. Dorsey.

FIG. 445.

The sac of the peritoneum pushed up and the external iliac artery raised on the ligature. Also ligature of the femoral at the point of election.

The ligation of this vessel is commonly required on account of aneurism of the common femoral and the lower part of the external iliac.

The results of the operation may be learned from the tables of Norris,* Cutter,† and Morton,‡ which embrace 157 cases of deligation of the external iliac for various causes, of which number 48 died and 109 recovered. The fatality attending the operation, when done for shot wounds, is well illustrated in the surgery of our late war, in which the external iliac was ligated 16 times, with only 2 successes. Gangrene and hemorrhage were the chief causes of death in the fatal cases, though a few perished from peritonitis, tetanus, and protracted constitutional irritation.

* Norris's Contributions to Practical Surgery, Philadelphia.
† American Journal of the Medical Sciences, New Series, 48, July, 1864.
‡ American Journal of the Medical Sciences, April, 1876.

Ligation of the Epigastric Artery.

The epigastric arises from the external iliac artery three or four lines above Poupart's ligament. It lies between the peritoneum and the transversalis fascia, and behind the spermatic cord, at the internal abdominal ring. The artery, accompanied by its two veins, runs upwards and inwards to the rectus abdominis muscle, and is covered anteriorly by the integument, the aponeurosis of the external oblique, and by the internal oblique and transversalis muscles.

The course of the vessel is indicated by a line extending from the middle of Poupart's ligament to the umbilicus.

Operation.—Make an incision two and a half to three inches long half an inch above and parallel with the course of Poupart's ligament, the middle of which shall be directly opposite the middle of the ligament; one or two vessels in the superficial fascia will probably require ligation. Next the tendon of the external oblique should be raised and divided on the director; then turn up the lower border of the fibres of the internal oblique and transversalis muscles, and, after tearing through the fascia transversalis, the artery will be exposed near to its origin, where, after being separated from its veins, it can be tied.

The same incisions will answer for the ligation of the circumflex ilii artery. After tearing through the transversalis fascia, this vessel will be found running parallel with, and close to, Poupart's ligament.

Both the epigastric and circumflex ilii arteries are exposed to injury from wounds of the abdominal parietes, and under such circumstances demand the application of a ligature. The readiness with which the blood from these vessels, when they are wounded, presses its way between the broad muscles of the belly, should always teach the surgeon the folly of relying on pressure for its control.

Ligation of the Internal Iliac Artery and its Branches.

Surgical anatomy.—The internal iliac artery leaves the common iliac at the sacro-iliac junction. The peritoneum and the ureter are in front of the vessel; the internal iliac vein and the lumbo-sacral nerve lie behind; and on its outer side is the psoas magnus muscle.

Operation.—The vessel is reached by the same incisions as have been described for the ligation of the external iliac artery, and the detachment of the peritoneum is to be conducted in precisely the same manner, differing from the other only in the necessity of a more extensive and higher separation of this membrane in order to reach the vessel, in doing which the operator should follow the external iliac artery until the internal trunk has been reached. It may be necessary to enlarge the wound in the parietes, upwards and outwards, in order to allow of free access to the vessel. In placing the ligature, the needle, after the denudation of the vessel, should be carried from within outwards, keeping close to the artery, so that the vein, which is behind and to the inner side, may not be damaged. The trunk of the internal iliac varies in length in different individuals. It rarely exceeds one and a half inches, but is sometimes found not to exceed one inch. It has been observed very truly by anatomists that the lengths of the external iliac and common iliac arteries bear a certain compensatory relation to each other,—that when one is shorter than normal the other is longer than usual.

Ligation of the internal iliac has been done for aneurism of its branches, and on account of hemorrhage.

The artery was first tied in 1812, by Stevens, of Vera Cruz, since which time it has been frequently ligated. (See Gluteal Aneurism.)

Ligation of the Gluteal and Ischiatic Arteries.—These vessels emerge from the pelvis through the great sacro-ischiatic foramen, and are separated from each other by the pyramidalis muscle, the gluteal being above and the ischiatic below. Both vessels are accompanied by a large nerve and by companion veins. (Fig. 446.)

Operation.—When the ligation of either of these vessels becomes necessary in consequence of a wound, it will be proper to follow and enlarge the external opening; but when undertaken for aneurism, it will be very important first to ascertain the position of the vessels by projecting a line or by touching certain prominences of the skeleton.

Fig. 446.

Posterior view of the pelvis. Gluteal artery seen coming out of the sacro-ischiatic foramen above the pyriform muscle, and the ischiatic below, each accompanied by a nerve.

Let the surgeon place the patient upon his face, with the pelvis somewhat raised over a folded pillow. Next let him feel for the following parts: 1, the posterior inferior spinous process of the ilium; 2, the tuberosity of the ischium; and, 3, the trochanter major of the femur. These being ascertained, let a line be drawn from the first of these prominences to a point midway between the last two. An incision should now be made in the course of this line, and to its whole extent, dividing successively the skin, the superficial fascia, and the sheath of the gluteus maximus muscle. This done, the surgeon next opens one of the fissures between the coarse fasciculi of the muscle, and, separating its sides, at once introduces a finger and feels for the sacro-sciatic foramen, and, carrying the digit upwards in order to discover its bony margin, detects the artery as it turns over this lip of the depression towards the dorsum of the ilium. It only remains to have the sides of the deep wound held asunder by retractors while the vessel is being isolated and tied.

If it be the ischiatic which requires the ligature, the incisions will be precisely the same as those for the deligation of the gluteal artery. In making the search for the vessel, however, the finger must be carried below the pyriform muscle, and swept round the muscle and the sharp edge of the sacro-ischiatic ligament until the ischiatic artery is felt.

Ligation of the Primitive Iliac Artery.

Surgical anatomy.—The abdominal aorta divides into the two common iliac arteries on the left side of the body of the fourth lumbar vertebra, a point directly posterior to the corresponding side of the umbilicus. The iliac arteries, after their origin, diverge right and left, and at the sides of the sacro-iliac articulation they divide into two trunks, the internal and the external iliac.

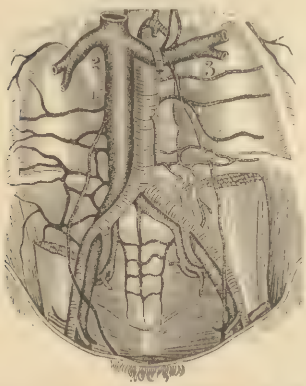
The common iliac arteries are about two inches in length. The right vessel, in consequence of having to pass across the body of the fifth lumbar vertebra, is longer than the left. The surgical relations of the two vessels are not identical.

The right iliac artery is covered in front by the peritoneum, the ileum, and at its termination by the ureter. Behind are placed the two primitive iliac veins, and on its outside lie the inferior vena cava and the right iliac vein.

The left iliac artery is covered anteriorly by the peritoneum, the rectum, and the superior hemorrhoidal artery, and at its termination by the ureter. The left primitive iliac vein is on the inner side and also behind the artery. (Fig. 447.)

Operation.—The incision required for the ligation of the common iliac artery does not differ from that employed in exposing the external and internal iliacs, except in the single particular of prolonging the cut to a higher point (two inches) above the anterior spinous process of the ilium, which gives to the wound a curvilinear form.

Fig. 447.



Relation of the common, external, and internal iliac arteries to their accompanying veins.

Fig. 448.

Enlargement of the collateral vessels after ligation of the common iliac artery.—From a preparation of Dr. Peace's.

The course of the vessel can be ascertained by drawing a line from the umbilicus to the middle of Poupart's ligament. In order to expose the vessel, it is necessary to detach the sac of the peritoneum beyond the limits of the iliac fossa, following closely the external iliac artery to the internal iliac, and from thence to the common trunk, at the same time pushing the ureter outwards. The peritoneum must be held out of the way by an assistant, in order that the vessel may be separated from its surrounding connections and the ligature passed round its trunk. The greatest gentleness and care must be observed not to injure the veins, an accident which will be best avoided by passing the deligating instrument from within outwards.

The operation of tying the common iliac is most commonly done for aneurism, but may become necessary on account of wounds. When, in consequence of the former disease, there has been an inflammatory adhesion of the peritoneum to the sac, or to the iliac fascia, the ligation may be one of great embarrassment, from the difficulty which will be experienced in separating without perforation the serous sac from its attachments.

The subsequent treatment is the same as has been described after ligation of the external iliac artery.

Collateral Circulation.—The vessels chiefly concerned in establishing the circulation of the inferior extremity after the ligation of the common iliac, are the ilio-lumbar and the obturator from the internal iliac, with the lumbar arteries from the aorta and the internal circumflex from the profunda femoris. The circumflex ilii from the external iliac vessel also communicates with the lumbars. In addition to these, the hemorrhoidal branches of the internal iliac anastomose with the hemorrhoidal branches of the inferior mesenteric, and the lateral with the middle sacral. (Fig. 448.)

The primitive iliac artery was first ligated by Professor William Gibson, in the year 1812. The operation was done in consequence of hemorrhage from a gunshot wound. Thirteen days after the vessel was tied the patient died from a renewal of the bleeding. Dr. Valentine Mott, in 1827, for the first time, ligated the common iliac artery for aneurism. The vessel has been tied sixty-three times, with fifty deaths, twelve recoveries, and one without known result. The following table includes a statement of these operations:

Table of Ligations of the Primitive Iliac Artery.

No.	Side.	Sex.	Age.	Disease.	Operation and Date.	Result. Cure.	Result. Death.	Remarks.	Reference.
1	.....	M.	38	Hemorrhage from shot wound.	W. Gibson, Philadelphia, 1812.	......	1	Death occurred on the 13th day.	American Med. Recorder, vol. iii.
2	R.	M.	33	Aneurism external iliac.	Mott, 1827.	1	......	....	Amer. Jour. Med. Sci., vol. i. p. 156.
3	R.	M.	30	Aneurism external iliac.	Crampton, 1828.	......	1	Death on the 4th day.	Medico-Chir. Trans., vol. xvi.
4	.....	M.	8	Secondary hemorrhage.	Liston, 1829.	......	1	Death in 24 hours.	London Med. Gaz., April 24, 1830.
5	.....	F.	......	Supposed aneurism.	Guthrie, 1833.	1	......	Death 8 months after. Not from ligation.	London Med. Gaz., vol. ii., 1834.
6	R.	M.	......	Aneurism external iliac.	Stevens, 1836.	......	1	Death on the 2d day.	Amer. Jour. Med. Sci., July, 1860.
7	L.	M.	38	Aneurism external iliac.	Salomon, 1837.	1	......	....	Zeitschr. für d. Gesammte Wissenschaft., Bd. vii., Heft iii., 1839.
8	.....	.....	......	Aneurism external iliac.	Garviso, 1837.	......	1	Death in 4 hours.	Annal. de la Chir., Nov. 1844.
9	.....	.....	......	Hemorrhage from external iliac.	Pirogoff, 1838.	......	1	Death in 14 days, from hemorrhage.	Annalen d. Chirurg Abtheil. d. Clinicum der Kaiserl. Universität, Dorpat, 1839.
10	.....	F.	2 m.	Anastomosing aneurism of the labium.	Bushe, 1839.	......	1	Death in 5 weeks.	N. Y. Med.-Chir. Bulletin, vol. i.
11	.....	M.	42	Aneurism external iliac.	Deguise, 1840.	1	......	The aneurismal sac and the iliac vein were wounded in this case in tying the artery.	Gazette Médicale, May, 1840.
12	.....	M.	20	Hemorrhage from wound of the aneurismal sac.	Post, 1840.	......	1	Died 1st day, from hemorrhage.	N. Y. Jour. Med. and Surgery, vol. iii.
13	R.	M.	36	Aneurism external iliac.	Peace, 1842.	1	......	Died 15 months after, from a return of the aneurism and subsequent hemorrhage.	American Journal of the Medical Sciences, April, 1843.
14	L.	M.	41	Aneurism external iliac.	Hey, 1843.	1	......	....	Medico-Chir. Trans., vol. xxvii.
15	.....	.....	......	Aneurism.	Garviso, 1843.	1	......	....	An. de la Chir., Nov. 1844, and Jour. de Chirurgie, 1846.
16	.....	M.	42	Malignant tumor.	Stanley, 1845.	......	1	Death on the 3d day, from peritonitis. The ligation was done under the supposition that the disease was aneurism.	Medico-Chir. Trans., vol. xxviii.
17	L.	M.	53	Aneurism external iliac.	Lyon, 1847.	......	1	Died from exhaustion in 50 hours.	Monthly Jour. Med. Sciences, vol. viii.
18	.....	M.	49	To prevent hemorrhage.	Chassaignac, 1850.	......	1	Died in 11 hours.	Bulletin de la Société de Chir. de Paris, Paris, 1851.
19	R.	M.	34	Aneurism external iliac and femoral.	Jones, 1851.	......	1	Died from erysipelas, 15th day.	London Jour. Medicine, vol. iv.
20	L.	M	25	Aneurism external iliac and femoral	Wedderburn, 1852.	......	1	Died from gangrene, 4th day.	New Orleans Medical and Surgical Jour., May, 1852.
21	.....	M.	52	Malignant tumor.	Moore, 1852.	......	1	Died in 14 days. The case was mistaken for aneurism.	Lancet, February 21, 1852.

Table of Ligations of the Primitive Iliac Artery.—(Continued.)

No.	Side.	Sex.	Age.	Disease.	Operation and Date.	Result. Cure.	Result. Death.	Remarks.	Reference.
22	.....	M.	26	Aneurism.	Uhde, 1852.	......	1	Died on the 4th day, from peritonitis. Internal iliac ruptured in tying the artery.	Deutsche Klinik, No. xvi., April, 1853.
23	.....	M.	46	Aneurism external iliac.	Van Buren, 1853.	......	1	Died on 4th day, suppuration of the sac.	New York Journ. of Med., Jan. 1857.
24	.....	M.	27	Rupture of internal iliac aneurism.	Edwards, 1857.	......	1	Died on the 25th day, from hemorrhage.	Monthly Jour. Med. Sciences, Jan. 1858.
25	.....	M.	24	Ischiatic aneurism.	Holt, 1857.	......	1	Died on the 3d day, from exhaustion. This is the case of ligation generally attributed to Dugas. The ischiatic of the same patient had been previously tied by Dugas.	Southern Medical and Surgical Journal, October, 1859.
26	.....	M.	59	Supposed aneurism.	Meier, 1857.	......	1	Died from gangrene on the 12th day.	Amer. Med. Gazette, May, 1859.
27	.....	M.	20	Hemorrhage from a stab in the groin.	Parker, 1858.	......	1	Died in 10 hours, from exhaustion.	Am. Jour. Med. Sci., July, 1860, New Series.
28	.....	M.	40	Hemorrhage.	Buck, 1858.	......	1	Died from hemorrhage in 17 days.	New York Journal of Med., Nov. 1858.
29	R.	F.	33	Aneurism external iliac.	S. Smith, 1858.	......	1	Died from hemorrhage on 48th day.	New York Journal of Med., March, 1860.
30	L.	M.	36	Aneurism external iliac.	Stone, 1859.	......	1	Died from dysentery in 26 days.	New Orleans Medical and Surgical Journal, Sept. 1859.
31	.....	.....	......	....	De Lisle, 1859.	......	1	Died in 13 weeks.	Statistical Sanit. and Med. Reports, London, 1862, p. 453.
32	L.	M.	40	Aneurism external iliac.	Goldsmith.	......	1	Died from exhaustion on 5th day.	Louisville Med. Journal, Feb. 1860.
33	R.	M.	31	Aneurism external iliac.	Syme, 1838.	......	1	Died from gangrene on 4th day.	
34	.....	.....	......	....	Gurlt.	......	1	....	*Langenbeck's Archives, 1862, B. iii. S. 96.
35	.....	.....	......	....	Bilnger.	......	1	....	*Fick, Cassel, 1836.
36	R.	M.	39	Aneurism iliac artery.	Bickersteth.	1	......	Ligature separated from the artery in 33 days.	Edinburgh Medical Journal, July, 1862.
37	R.	M.	......	Iliac aneurism.	Cock, 1864.	1	......	....	*Guy's Hospital Reports, 1864, 3d Series, vol. x.
38	.....	.....	......	Secondary hemorrhage.	McKinley.	1	......	....	*Edin. Med. Jour., 1864, vol. ix. P. II. p. 808.
39	.....	.....	......	Arterio-venous aneurism of external iliac artery and vein.	Hargrave.	......	1	....	*Dublin Med. Press, 1865, vol. ii. p. 169.
40	R.	.....	......	Aneurism of aorta.	Baxter.	......	1	....	*Chicago Med. Jour., 1866, vol. xxiii. p. 460.
41	R.	.....	......	Inguinal aneurism.	Maunder.	......	1	Died in 7 days.	Med. Times and Gaz., October 26, 1867.
42	.....	.....	......	Shot wound in upper part of femur.	Czerny.	......	1	Died in 4 hours. The external iliac was first tied.	*Billroth, Chirurg. Briefe, u. s. w., Berlin, 1872, S. 131.
43	.....	.....	......	Spontaneous aneurism.	Ladureau.	......	1	Died in 30 days.	*Rec. de Mém. de Milit., Oct. 1871.
44	.....	.....	......	Abscess from sacro-iliac disease.	Baker.	......	1	Died in 40 hours.	*St. Bartholomew's Hosp. Rep., 1872, vol. viii. p. 120.
45	R.	.....	......	....	Busch.	......	1	Died in 40 days.	*Langenbeck, Arch. f. Klin. Chir., 1873, B. xv. S. 481.
46	L.	M.	......	Shot wound of pelvis.	Prof. Brainard.	......	1	Died in 3 months.	*Chicago Med. Jour., March, 1864, vol. xxi. p. 97.
47	L.	M.	......	Shot wound.	McKee.	......	1	Died in 2 days.	*Med. and Surg. Hist. Rebellion, Part II. surg. vol., p. 334.
48	R.	.....	......	Traumatic aneurism.	Isham.	......	1	Died 4th day.	*Chicago Med. Jour., 1860, vol. xxiii. p. 222.

Table of Ligations of the Primitive Iliac Artery.—(Continued.)

No.	Side.	Sex.	Age.	Disease.	Operation and Date.	Result. Cure.	Result. Death.	Remarks.	Reference.
49	.....	.....	.....	Arterio-venous aneurism of external iliac artery and vein.	Cutter.	......	1	Died.	Amer. Jour. Med. Sci., 1864, vol. xlviii. p. 36.
50	.....	M.	......	Shot wound of the pelvis.	Hamilton, 1864.	......	1	Died.	Hamilton's Surgery, p. 232.
51	.....	.....	......	....	Ingram.	......	1	Died.	*Dr. Otis.
52	.....	.....	......	....	Hammond, 1861.	......	1	....	Gross's Surgery, vol. i. p. 810.
53	.....	.....	......	....	Luzenburg, 1846.	1	......	....	Gross's Surgery, vol. i. p. 810.
54	.....	.....	......	....	Watson.	......	1	The abdominal aorta was afterwards tied in this case.	
55	.....	.....	......	....	D'Almeida.	......	1		
56	.....	.....	......	....	Pitta.	......	1	....	¶Gaz. Médicale, October 3, 1874.
57	.....	.....	......	....	Caldas.	1	......	....	British Med. Journal, July 1, 1876.
58	.....	.....	......	Aneurism external iliac.	Gouley, about 1872.	.....	1	Died in a few days, from exhaustion.	New York Medical Jour., July 1, 1876.
59	L.	M.	......	Iliac aneurism.	Barral.	......	1	Died.	¶Gaz. Médicale, October 3, 1874.
60	L.	M.	62	Iliac aneurism.	Barbarossa, 1874.	......	1	Died on the 26th day.	¶Gaz. Médicale, October 3, 1874.
61	L.	M.	40	Femoral aneurism.	Hunter, 1877.	......	1	Died 3 days after. In this case the femoral had been 3 times tied, the obturator once, and the external iliac once.	Done in the University Hospital, Philadelphia.
62	.....	.....	......	Femoral aneurism.	Dr. A. Mott, 1877.	......	......	Result not ascertained.	Phila. Med. Times, Oct. 13, 1877, p. 17.
63	.....	.....	......	Hemorrhage after ligation of the femoral (popliteal aneurism).	Dr. Carr.	......	1	Died on the 40th day from gangrene and hemorrhage.	¶Medical Record, Sept. 29, 1877, p. 613.
						12	50		

All those marked with * have been taken from Dr. Otis's Medical and Surgical History of the Rebellion.
Those marked with ¶ have been taken from Dr. Ashhurst's memoranda.

Ligation of the Abdominal Aorta.

In order to expose and to tie the abdominal aorta, an elliptical incision from five to six inches in length should be made, with its concavity towards the median line, commencing at the cartilage of the tenth rib and terminating one inch below the anterior superior spinous process of the ilium. The cutaneous, fascial, and muscular layers being divided, the peritoneum is to be separated, in the direction of the spine, from the fascia transversalis and the subjacent parts, as in the operation on the iliac artery. When the aorta has been reached, the next step consists in isolating it from the branches of the sympathetic, which overlie its walls, and also from the ascending cava, which lies along its outer side. When this has been effected, the ligature should be passed from right to left, so as to elude the vein.

Sir Astley Cooper was the first to tie the abdominal aorta, in 1817. He approached the vessel by opening both the parietal and the visceral layer of the peritoneum. The patient survived forty hours. The operation has been repeated seven times, always on account of aneurism, and in each instance with a fatal result. The operators were James, Murray, Monteiro, South, McGuire, Stokes, and Czerny. In James's case the artery was exposed after the manner of Cooper. The man lived only a few hours. Monteiro's operation is exceedingly interesting, from the fact that his patient lived for nearly

ten days after the ligation. In Stokes's case the aorta was compressed by means of a silver wire. Death followed in twelve hours.

Ligation of the Femoral Artery.

Surgical anatomy.—The femoral artery occupies the anterior and inner portions of the thigh. It is crossed by the sartorius muscle, and is thus divided into two unequal portions. The first, or that portion above the sartorius, occupies Scarpa's triangle,—that is, a space which is bounded on the outside by the sartorius muscle, on the inside by the adductor longus muscle, above by Poupart's ligament (the base), and below (the apex) by the intersection of the sartorius and adductor longus. This triangle answers to what is called the hollow of the thigh. The femoral artery in Scarpa's triangle is covered in front by the skin, the superficial fascia, the deep fascia, and the crural branch of the genito-crural nerve. On the inside it is in relation with the femoral vein for the first two inches of its course, after which the vein passes behind the artery, and near the apex of the triangle gets to its outer side. The anterior crural nerve is situated some distance to the outer side; though one of its branches, the internal saphenous, runs down the thigh close to the outer side of the artery. (Fig. 449.) After the femoral artery passes beneath the sartorius muscle it enters an aponeurotic canal, formed between the adductor magnus and the vastus internus muscles (*canal of Hunter*), after which it perforates the adductor and enters the ham. While in the aponeurotic canal the artery is covered by the skin, the superficial fascia, the saphena magna vein, the sartorius, the aponeurosis, and the internal saphenous nerve, which, though in the canal, is not in the sheath of the vessels. (Fig. 450.) The vein is external to the artery. The course of the femoral artery will be indicated by a line drawn from a point midway between the anterior superior spinous process of the ilium and the symphysis pubis, to the tuberosity of the internal condyle of the femur. The arteries given off by the femoral are the superficial epigastric, superficial circumflex iliac, and superficial pudic, the profunda femoris, the muscular, and the anastomotica magna. The branches of the profunda femoris are the two circumflex and the three perforating arteries.

FIG. 449.

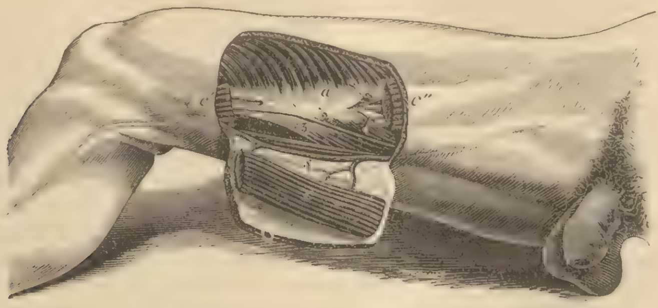
A view of the contents of Scarpa's triangle. Femoral artery passing from the base to the apex of the triangle; femoral vein inside, behind, and on the outside of the artery; anterior crural nerve external.

The femoral artery may require ligation on account of aneurism and for wounds. The success which has within the last few years attended the use of pressure for the cure of aneurism has in a great measure done away with the necessity for tying this vessel. The most favorable position in which to apply a ligature is at the apex of Scarpa's triangle, a point farthest removed from the profunda femoris artery, and consequently the one at which ligation is least likely to be followed by secondary hemorrhage. This is the operation of Hodgson, and is in itself attended with little danger. Scarpa tied the vessel in the middle of the triangle, and Hunter in the aponeurotic canal.

Ligation above the profunda femoris, which at one time was deemed a

very dangerous and unsurgical procedure, has within the last few years been regarded with more favor, in consequence of the success which has at-

FIG. 450.



Femoral artery in Hunter's canal: flap turned down, consisting of skin, fascia, saphenous vein, *s*, and sartorius muscle, *c*; *a*, vastus internus; 5, tendon of the adductor magnus; 2, adductor longus; near *c''* the aponeurotic canal is opened for a short distance, exposing the femoral vessels.

tended the operation in the hands of the Dublin surgeons. Five successful ligations of the common femoral have been reported by Dr. G. H. Porter,* and Dr. Macnamara† alludes to eight cases of a similar ligation (strictly speaking, seven, as in one of the cases the ligature was applied below the profunda), of which number one died. Professor Gross has tied the common femoral in two instances, with one recovery and one death. In the fatal case the artery was extensively diseased.

Dr. Mott has spoken favorably of this operation as one which he had frequently done with satisfactory results. Though the question may be considered as still *sub judice*, yet if the coats of the artery when exposed were found to be sound, I should have no hesitation in making the deligation in this portion of the vessel; if the coats were found to be diseased, however, I should feel it my duty to abandon the common femoral and select the external iliac as the safer operation. Considered in the aggregate, ligation of the femoral has been attended with great success. Of the 204 instances contained in the tables of Dr. Norris, only 50 proved fatal. At Guy's Hospital the femoral artery has been tied during the last fourteen years for aneurism 24 times, with 1 death, and at St. Bartholomew's 15 times, with 3 deaths.‡ Syme tied this vessel 23 consecutive times without a single death. Between the years 1868 and 1876 the femoral artery was ligated at the Pennsylvania Hospital 11 times, with 2 deaths.§

OPERATION ON THE COMMON FEMORAL.—A vertical incision two and a half inches in length should be made, beginning at the middle of the lower border of Poupart's ligament. After raising and dividing the superficial fascia, one or two inguinal lymphatic glands will probably be exposed, which can be pressed out of the way by breaking up the surrounding connective tissue with the director. Should one or two cutaneous vessels spring at this stage of the operation, they must be secured. After a little clearing away of loose fat and connective tissue, the sheath of the artery will be exposed, and should be opened. The vessel being now separated from the sheath of the vein on the inside, and from a branch of the genito-crural nerve which lies on its anterior surface, the needle should be passed from within outwards, and the thread applied within half an inch of Poupart's ligament.

OPERATION AT THE POINT OF ELECTION.—To tie the femoral at the apex of Scarpa's triangle, the limb should be flexed, abducted, and laid on its outer surface. An incision three inches long should now be made, beginning

* Dublin Quarterly Journal, Nov. 1860. † British Medical Journal, October 5, 1867.

‡ Bryant's Surgery, p. 217.

§ Morton, Statistics of Ligation of Arteries in the Pennsylvania Hospital, American Journal of the Medical Sciences, 1876.

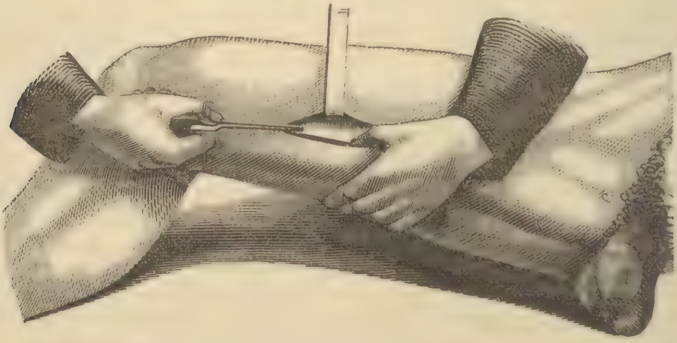
three finger-breadths below the middle of Poupart's ligament, and carried obliquely to the longitudinal axis of the limb, that is, in the course of the femoral artery, or in the direction of a line extended from the middle of Poupart's ligament to the most prominent portion of the internal condyle of the femur. After dividing the skin and the superficial fascia, the deep fascia should be opened, exposing the inner edge of the sartorius, which may be recognized by the oblique course of its fibres. Turning slightly back the border of this muscle, the sheath of the femoral vessels will be seen, and the pulsation of the artery may be felt. Much care is required after opening the sheath to denude the vessel, so as to pass the thread without damage to the accompanying vein, which lies behind and to the outer side of the artery. To avoid this accident in passing the ligature, the needle, or other instrument used for the purpose, should be carried from without inwards. (Fig. 451.) A small vessel is often divided in this operation close to the sheath, and should always be tied. I have witnessed a troublesome bleeding from a neglect on this point.

Fig. 451.

Ligation of the femoral artery at the apex of Scarpa's triangle.

Operation in the Aponeurotic Canal.—The femoral artery may be tied below the sartorius, as was done by Hunter, though, except under circumstances rendering the operation in Scarpa's triangle impracticable, or when a wound involves the vessel at the middle of the thigh, this operation is not a desirable one. When undertaken, an incision should be made, beginning at the apex of Scarpa's triangle and continued downwards and inwards, in the line already given, and terminating three and a half inches above the internal condyle of the femur. In dividing the skin and the cellulo-adipose tissue, avoid any branches of the internal saphenous vein or the long saphenous nerve which may lie in the way of the incisions; next open the deep fascia which encases the sartorius muscle, and, drawing the latter downwards, expose the aponeurosis which forms the anterior wall of the vascular

Fig. 452.



Ligation of the femoral artery in the aponeurotic canal. Retractor holding the wound open, and the director passed underneath the fibrous wall of the canal preparatory to its division.

canal. The parts being now held asunder, the surgeon makes a small opening in the aponeurosis, into which he passes the director and slits it up, in order to uncover the artery. (Fig. 452.) After separating the artery from the vein which lies to its outer side, the needle should be passed from without inwards.

Peculiarities of distribution.—The femoral artery in a few instances has

been known to divide below the profunda into two branches, which passed down the thigh side by side and at the aponeurotic canal became united into one branch to form the popliteal. Sometimes the artery divides into two trunks high up on the thigh, one of which splits, forming the posterior tibial and the peroneal. Such an irregularity would possess great importance in aneurism of the femoral or of the popliteal, as the wrong vessel might be tied, and the tumor be in no way affected by the ligature. Cases of popliteal aneurism have been recorded in which this abnormal arrangement existed, and where it became necessary to ligate both branches. In rare instances the femoral artery has been found absent from the front of the thigh, having passed through the sacro-sciatic foramen and descended along the posterior aspect of the limb.

The origin of the profunda has also a surgical interest. While it usually arises from the femoral two inches below Poupart's ligament, yet its commencement is frequently within one inch of the latter, and in one or two cases it has arisen from the external iliac artery.

Collateral circulation.—When the femoral artery is tied below the profunda femoris the blood finds its way to the inferior part of the limb principally through the communication which exists between the perforating branches of the profunda and the anastomotica magna of the femoral, with the articular arteries of the popliteal and the recurrent branch from the anterior tibial artery.

When a ligature is applied to the femoral artery above the profunda, the blood is conveyed to the femoral below, mainly by the ischiatic, gluteal, and obturator arteries from the internal iliac, with the internal and external circumflex arteries from the profunda femoris.

Ligation of the Popliteal Artery.

Surgical anatomy.—The popliteal region, or ham, is a lozenge-shaped space, the sides of which are formed by the inner and outer hamstring tendons above, and the heads of the gastrocnemius muscle below. The region is formed at the expense of the lower third of the thigh and something less than the upper fourth of the leg. The femoral artery enters the ham after perforating the adductor magnus muscle, passing directly through its middle, and terminates, after running through the tendinous arch of the soleus muscle, at the lower border of the popliteus muscle. It is accompanied by the popliteal vein and nerve. The vessel gives off the several arteries to the gastrocnemius muscle, the four articulars—two external and two internal—and the azygos branch to the ligaments and the inside of the knee-joint. In the middle of the ham the vessel is covered by the skin, the superficial fascia, the deep fascia, and a quantity of adipose tissue. In the superficial fascia runs the external saphenous vein. At the upper part of the popliteal region, in addition to the above-named structures, there is the semi-membranosus muscle, and at the lower part, the gastrocnemius, the plantaris, and a small part of the soleus in front of the artery. Behind, the vessel, after passing the adductor magnus, rests first upon the inner and posterior surface of the femur, then upon the posterior ligament of the knee-joint, and last, upon the popliteal fascia. On a plane more superficial and external to the artery lies the popliteal vein, and still more externally and superficially is situated the popliteal nerve.

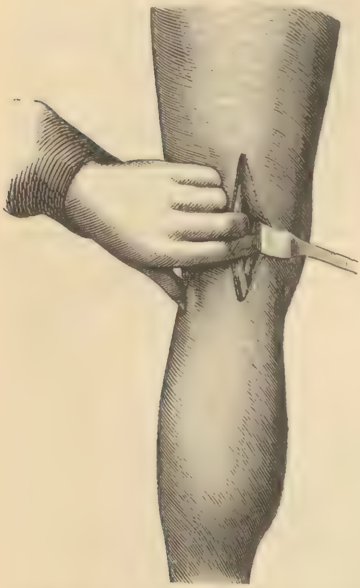
The popliteal artery occasionally separates into its terminal branches—anterior and posterior tibial arteries—in the middle of the ham, and in rare instances it divides like an axis into three trunks, namely, into the two tibial arteries and the peroneal artery.

Operation at the upper third.—Place the patient on the breast, with the limb extended, then make an incision three and a half inches in length along the external border of the semi-membranosus muscle, commencing at the inferior third of the thigh. The skin and the fasciæ having been divided, the under-

lying fatty tissue should be broken up with the director or a finger, after which the nerve will be exposed, superficial and external to the artery. A little deeper will be found the vein, also external to the vessel. After its denudation, the artery can be encircled by the ligature carried from without inwards, in order that neither the vein nor the nerve shall be included.

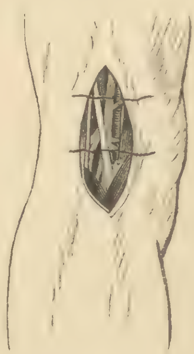
At the lower third.—The patient occupying the same position as in the preceding operation, make an incision three inches in length, beginning directly opposite the knee-joint, a little external to the median line,—the internal head of the gastrocnemius being somewhat larger than its fellow on the opposite side. After laying open the skin, examine in the superficial fascia for the external saphenous vein, which must be thrust aside; next divide the fascia, when the interval between the two heads of the gastrocnemius will be exposed. The limb must now be slightly flexed, in order to relax the two portions of the muscle, which should be separated by running the finger up and down the cellular interval between them. At the bottom of this space will be found first the nerve, next to the inside the vein, and still deeper and externally the artery. The operator should now draw the nerve and the vein towards the inner side of the limb (Fig. 453), while the needle bearing the ligature is passed around the artery from within outwards. (Fig. 454.)

Fig. 453.



Ligation of the popliteal. Two fingers are in the wound, one holding aside the nerves and the other searching for the vessels.

Fig. 454.



Popliteal artery exposed, and the ligature passed at the upper and the lower third.

The middle portion of the popliteal artery, in consequence of its great depth, is unfavorably placed for ligation, and is, accordingly, not the subject of operation.

Except for traumatic aneurism, or in the event of a wound, the circumstances which will require the application of a ligature to any portion of the vessel will be rarely encountered.

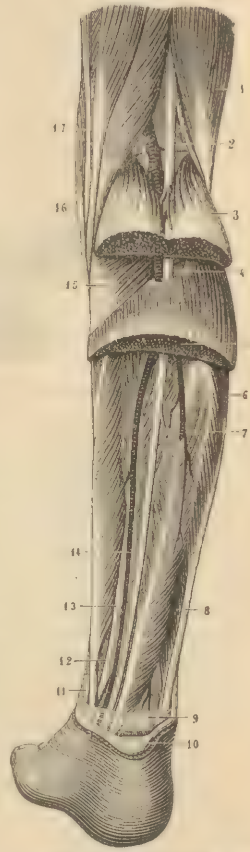
Ligation of the Posterior Tibial Artery.

Surgical anatomy.—The posterior tibial, the larger of the two branches of the popliteal artery, begins at the lower border of the popliteus muscle, and runs down the back part of the leg, crossing, as it descends, to the tibial side. In the deep concavity between the inner ankle and the os calcis and underneath the arch formed by the two origins of the abductor muscle of the great toe, the vessel divides into two branches,—the external and internal plantar arteries, which are destined to supply the sole of the foot. In its descent, the posterior tibial artery rests upon the tibialis posticus and flexor longus digitorum muscles; and at the lower part of the leg it lies on the posterior surface of the tibia and the internal lateral ligament of the ankle-joint. At the ankle the artery is situated between the tendons of the tibialis posticus and the flexor longus digitorum on the inside, and the flexor longus

pollicis on the outside,—a vein being placed on each side and the nerves external to the vessel. The artery is covered by the skin, the superficial and deep fasciæ, and the gastrocnemius and soleus muscles. The posterior tibial nerve—at first to the inner side of the artery—crosses over the latter, and at the middle and the lower third of the limb is found on its outside. (Fig. 455.)

The branches of the posterior tibial artery are the peroneal, the muscular, the communicating, the nutritious, and the calcanean.

Fig. 455.



Course of the posterior tibial artery: 3, the head of the gastrocnemius cut across; 4, posterior tibial nerve and popliteal artery passing under the tendinous arch of the soleus, 5, which is also cut across; 7, peroneal artery; 11, tendon flexor communis digitorum; 12, tendon tibialis posticus; 13, posterior tibial artery; 14, posterior tibial nerve.

Operation.—The posterior tibial can be tied at its upper, middle, and posterior thirds. The course of the vessel is in the direction of a line extended from the middle of the popliteal space to a point midway between the internal malleolus of the tibia and the tendo Achillis.

At the upper third.—The operation of tying the posterior tibial in its first part is one of considerable difficulty, and demands for its accomplishment an accurate knowledge of the appearances of the structures concerned. The artery is best approached from the inner side of the leg.

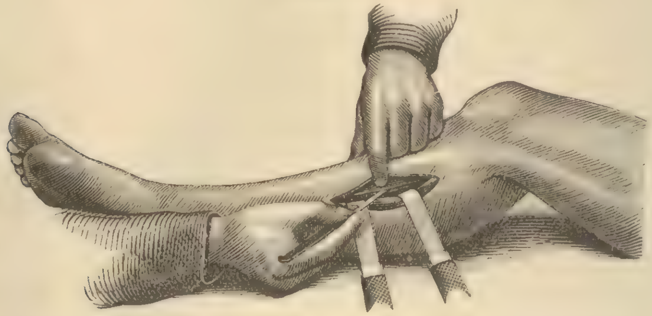
The leg being flexed, the limb is laid on its outer side, when, feeling for the inner angle of the tibia, the surgeon makes an incision three and a half or four inches in length along its edge, beginning two and a half inches from the upper end of the tibia. (See Fig. 457.) The skin being divided, care must be exercised, in opening the superficial fascia, not to injure the internal saphenous vein or nerve, both of which lie directly in the track of the wound. These structures being displaced, the deep fascia must be divided to the full extent of the integumental incision. It should also be cut transversely, so as to allow a freer access to the intermuscular parts. The next step consists in detaching the origin of the soleus muscle from the tibia. (Fig. 456.) It is at this stage of the operation that one of two errors is often committed, either of which will lead the operator astray. The first consists in opening the intermuscular space between the inner head of the gastrocnemius and the soleus muscle, and the second, in shaving off all the muscular tissue from the bone, by which the tibialis posticus muscle is raised along with the soleus. The first mistake leads the surgeon above the vessel, and the second leads him underneath. There is, however, a guide which will point in the right direction. If the soleus has been properly detached and raised, its under surface will present a white, shining sheet of tendinous material, beneath which will be seen a layer of fascia (intermuscular) covering the tibialis posticus muscle. If search be now made externally and towards the middle of the leg, the artery will be found covered by the intermuscular fascia, the nerve lying to its outer side. After the vessel has been separated from the investing connective tissue and the accompanying veins, the needle must be passed from without inwards.

At the middle third.—Make an incision two and a half inches long parallel with the inner edge of the tibia, and about half an inch from its border. After dividing the skin, the same precautions with regard to the saphenous vein and nerve will be required in cutting the superficial fascia as in the previous operation. It now remains to incise on the director the deep

fascia, and press outwards the inner margin of the soleus muscle, when the artery with its accompanying veins will be exposed, as also the nerve running along the outer side of the vessels. After isolating the artery from its satellite veins, the thread must be passed from without inwards.

At the inside of the ankle.—A semilunar incision one inch and a half in length should be made, midway between the internal malleolus and the tendo

FIG. 456.



Ligation of the posterior tibial at its upper third; wound held open by retractors while the surgeon detaches the origin of the soleus.

Achillis, the knife being held at right angles with the surface of the part. After dividing the skin and the superficial fascia, the deep fascia must be lifted upon a director and freely opened. (Fig. 457.) Immediately underneath should be found the vessel, with the tendons of the tibialis posticus and the flexor longus digitorum muscle on the inside, and the posterior tibial nerve and the tendon of the flexor longus pollicis muscle on the outside. After isolating the artery from its accompanying veins, the needle should be passed from without inwards.

The necessity for tying the posterior tibial may arise in consequence of traumatic aneurism, or of wounds inflicted by the fragments of a broken

FIG. 457.

Ligation of the posterior tibial above the ankle. Lifting the deep aponeurosis previous to isolating the artery.

bone. In spontaneous aneurism of the upper part of the vessel, it will be best to tie the femoral artery on the Hunterian plan.

Ligation of the Peroneal Artery.

Surgical anatomy.—The peroneal artery arises from the posterior tibial, about one inch below the lower border of the popliteus muscle, and, after passing across to the outer side of the leg, runs down the posterior and inner surface of the fibula to the lower third of the limb, where it supplies the anterior peroneal artery. The vessel diminishes so rapidly in size as it de-

scends, that below the middle of the leg it has become too small to require a formal ligation. The artery for the most of its course lies in the midst of the muscular fibres of the flexor longus pollicis pedis, in the angle formed by the inner surface of the bone and the interosseous ligament, and is also covered by the fibular origin of the soleus.

Operation.—Make an incision two and a half inches long over the external edge or angle of the middle of the fibula. Divide consecutively the skin, the superficial fascia, and the deep fascia. The origin of the soleus muscle will now come into view. This must be detached for a short distance from the fibula and pushed inwards, on doing which the edge of the bone will be distinctly exposed. The operator now divides the fibres of the flexor longus pollicis, and separates them from the posterior surface of the fibula, at the inner surface of which will be found the artery, at the point where the interosseous membrane joins the bone.

Ligation of the Anterior Tibial Artery.

Surgical anatomy.—At the lower border of the popliteus muscle the anterior tibial passes through an opening in the interosseous membrane and reaches the anterior portion of the leg, when it passes down the limb, becoming more superficial as it descends, and finally, after passing in front of the ankle, reaches the dorsum of the foot and becomes the dorsalis pedis artery.

Fig. 458.

Relation of the anterior tibial artery to the muscles of the leg.

At the upper third of the leg the anterior tibial is deeply situated, resting on the interosseous membrane. It is placed between the tibialis anticus and extensor longus digitorum muscles, having the anterior tibial nerve on its outer side. At the middle third it is lodged between the tibialis anticus muscle on the inside and the extensor proprius pollicis on the outside, with the nerve in front, and also on the outside.

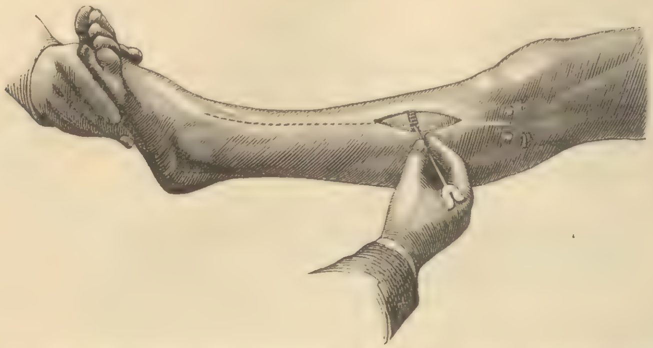
At the lower third, immediately above the front of the ankle, the artery lies between the tendons of the extensor proprius pollicis on the inside and the exterior longus digitorum on the outside, with the nerve also external in position. (Fig. 458.) The branches of the anterior tibial are the recurrent tibial, the muscular, and the external and internal malleolar.

Operation.—The anterior tibial artery may be tied in its upper, middle, and lower thirds. The general course of the vessel corresponds to a line drawn from a point midway between the tubercle of the tibia and the head of the fibula to the centre of the intermalleolar space. (See Fig. 459.)

At the upper third.—The limb being somewhat flexed, and supported on a pillow placed beneath the ham, an incision three inches long should be made equidistant from the tubercle of the tibia and the head of the fibula, and commencing on a level with the former. After cutting through the skin and the superficial fascia, the surgeon should endeavor to recognize the intermuscular space between the tibialis anticus and extensor longus digitorum muscles before opening the deep fascia. This may be done by noticing the presence of a yellow or fatty line beneath the aponeurosis; or one of the small arteries designed for the supply of the integument may be discovered perforating the fascia. In either case the proper route is indicated. The deep fascia must now be raised upon the director and freely laid open. As both muscles have an origin from a prolongation of the deep fascia, their separation

should be commenced at the lower angle of the wound, where the adhesion is less close. After opening the intermuscular space by the finger, the artery will be found at its bottom, resting on the interosseous membrane, with a vein on either side, and the nerve externally. After the denudation of the vessel the thread should be passed from without inwards. When difficulty is expe-

FIG. 459.



Line showing the course of the anterior tibial in the leg. Ligation at the upper third.

rienced in recognizing the different tendons in front of the ankle, they may be readily identified by moving the great toe, by flexing and extending the foot, and by similar movements of the other toes.

At the middle third.—The artery in this region is more superficial than in the upper third of its course. An incision three inches in length should be made in the direction of the line already described. After dividing the skin and the superficial and deep fasciæ, the fissure between the tibialis anticus and extensor longus digitorum muscles must be opened, when a third muscle, the extensor proprius pollicis, will be seen between the other two. The surgeon will now open and enlarge the fissure between the extensor proprius pollicis and the tibialis anticus, at the bottom of which lies the anterior tibial artery with its accompanying veins, and in front or close along its outer side is the anterior tibial nerve. After isolating the vessel, care must be taken to press the nerve towards the fibular side of the limb while the needle is being passed from without inwards.

At the lower third.—The artery is to be exposed one inch and a half above the ankle-joint. In consequence of the superficial position of the vessel, the incision need not exceed two inches in length, and should be made in the course of the indicated line, beginning three inches above the front of the articulation. After cutting through the skin and the superficial fascia, the deep fascia should be opened external to the outer border of the tendon of the extensor proprius pollicis, which is the second tendon from the tibia. By enlarging the intermuscular space between this tendon and the extensor longus digitorum the artery will be reached, having the nerve on its outer side. After the denudation, and while the ligature is being carried round the vessel from without inwards, the nerve must be pressed aside in the direction of the fibula.

The anterior tibial artery may require ligation on account of traumatic aneurism, or in consequence of wounds. The artery is occasionally torn in compound fractures of the leg, and requires, in such an event, the application of a ligature.

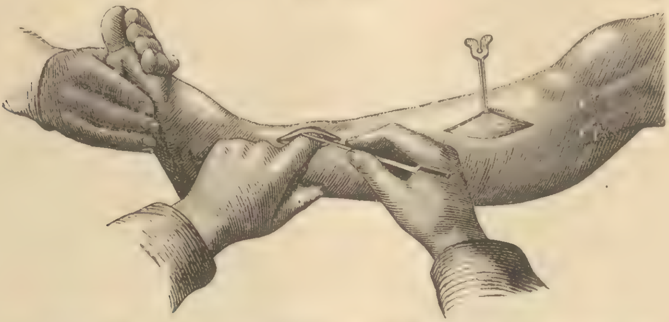
Ligation of the Dorsalis Pedis Artery.

Surgical anatomy.—The dorsal artery of the foot, which is but an extension of the anterior tibial, lies over the first interosseous space, and between the tendon of the extensor proprius pollicis on the inside and the innermost tendon of the extensor brevis digitorum on the outside, with the accompany-

ing nerve externally. It is covered by the skin, the superficial fascia, and the deep fascia.

Operation.—The vessel may be found in a line drawn from the middle of the anterior malleolar space to a point midway between the anterior extremity of the first two metatarsal bones. (Fig. 460.) An incision one inch long in

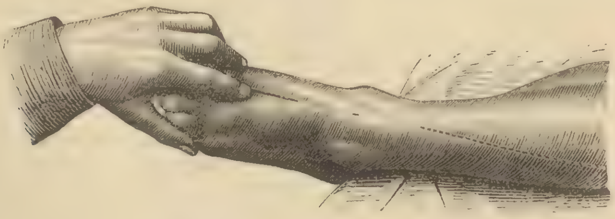
Fig. 460.



Ligation of the anterior tibial at the lower third of the limb or above the ankle.

the course of the line, or along the outer border of the tendon of the extensor proprius pollicis, should be made (Fig. 461), and after cutting through the skin, the superficial fascia, and the deep fascia, the artery will be found lying immediately internal to the inner tendon of the short extensor muscle

Fig. 461.



Incision for ligation of the dorsalis pedis.

of the toes. After isolating the vessel from its venæ comites, and pressing externally the nerve, the ligature may be passed from without inwards.

The dorsal artery of the foot will sometimes require to be tied, in consequence of wounds inflicted by chisels or other vulnerating bodies.

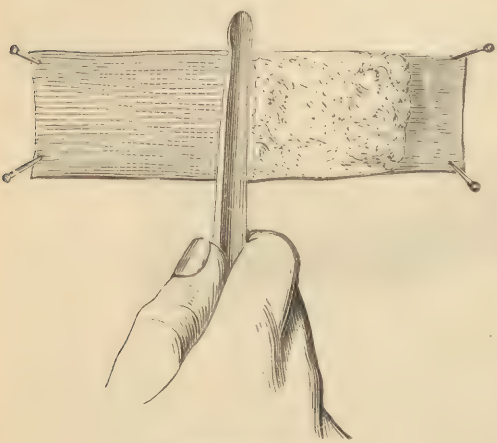
CHAPTER IX.

SURGICAL DRESSINGS.

UNDER the head of surgical dressings are included all those materials, appliances, and apparatus employed by the surgeon in the cleansing, uniting, protection, and support of wounds and abscesses, in the control of hemorrhage, in the correction, by mechanical measures, of deformities, and in the retention of broken bones and of displaced joints. In the present chapter, however, I shall speak only of those which are generally in use in the treatment of wounds and fractures.

Lint.—There are two kinds of lint, the common or domestic lint and the patent lint. Common lint is prepared by stretching a strip of old linen and scraping its surface with an ordinary table-knife until a soft, cottony mass is collected. (Fig. 462.)

FIG. 462.



Method of scraping lint.

Patent lint, so generally used in hospitals, is made from new linen, the transverse threads of which are removed, and the surface of the longitudinal ones scraped by machinery.

The absorbent power of lint is greatest when prepared from new linen. At present it is less used than formerly, other materials much less expensive having taken its place.

Charpie is made by unraveling or taking apart the threads of linen. During the War of the Rebellion vast quantities of this material were prepared by households, from old table-cloths and other pieces of linen.

The dressings which are constructed from charpie are the following:

Pellets.—These are little balls, made by rolling a mass of charpie into a round form between the palms of the hands. (Fig. 463.) They may be used to tampon wounds in order to arrest bleeding, or may be introduced in suppurating cavities to absorb the pus.

FIG. 463.

Pellet.

FIG. 464.

Tent.

Pellets differ from bullets in having the little ball covered with a piece of muslin or of linen, the edges of which are tied after the manner of a sack. (Fig. 463.)

They are useful as compresses for the arrest of hemorrhage, and as a temporary substitute for a truss in cases of hernia, being bound on the part with a roller.

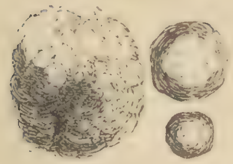
Tents are made by taking a little roll of charpie, doubling it upon itself, and then twisting it between the thumb and fingers into a cone. (Fig. 464.) The

tent can also be made of patent or domestic lint. It is used to keep patulous the opening of an abscess. After the contents have escaped, the apex is inserted into the incision made by the knife, and the tent is carried in to the proper extent by imparting to it a rotary motion.

Bullets are prepared by rolling pieces of charpie or lint between the fingers or the palms of the hands into round balls. (Fig. 465.) They may be used to absorb the discharges from a suppurating cavity, or to arrest hemorrhage from a wound.

The mesh.—The mesh is formed by placing a number of threads of charpie parallel to one another, and then either twisting the mass at the middle upon itself (Fig. 466), or tying a thread tightly around the centre. In the latter case it is often termed a *roll.* (Fig. 467.) The mesh or roll is used to pack fistulous openings, to prevent wounds from closing too soon, to absorb discharges, and to control hemorrhages. In its application a probe or a director

FIG. 465.



Bullets.

FIG. 466.

Mesh supported on a probe.

FIG. 467.

Roll.

FIG. 468.

Pledget.

is placed against the centre, at the point where it is twisted or tied, and in this way, when doubled upon itself, it can be conducted into a wound or sinus.

The pledget is a form of compress made by arranging the threads of charpie somewhat parallel with one another, turning their extremities inwards, and imparting a fixedness of form by compressing the mass between the palms of the hands. (Fig. 468.) In this way it can be fashioned into almost any form, square, oblong, or round.

The pledget is often placed over the ends of stumps after amputation, and also over other wounds, to absorb the discharges. Meshes, tents, and pledgets are sometimes smeared with simple cerate or sweet oil.

Other materials have been introduced into surgical practice cheaper than lint, and equally efficient, the most important being oakum and paper.

Oakum, introduced by Dr. Sayre, is made from old cast-off ropes, such as have formed a portion of the rigging of ships. Picking oakum at one time constituted a part of prison labor. When carefully prepared, it makes an excellent dressing, being soft, possessing good absorbent properties, and emitting a pleasant odor from the tar contained in the fibre. It may be used to wash wounds and to pad splints, and by shaping it into a cushion-like mass or ring it can be employed with great advantage to relieve salient parts of the body from pressure, such as those over the tuber ischii, over the sacrum, and upon the heel. This material is extensively used in all the Philadelphia hospitals.

Paper lint is made from old rags decolorized by chloride of lime and passed between rollers into sheets. It was first used as a surgical dressing by Dr. Studdeford, of Lambertville, New Jersey. I was induced to give it a trial in the Pennsylvania Hospital, and was led to believe that with certain improvements it could be made both an economical and a valuable dressing. These have been successfully carried out by Dr. Huffnagle, of New Hope, Pennsylvania. The preparations of this material now in use are the follow-

ing: a soft, pliable lint, possessing excellent absorbent properties, and applicable to every purpose for which patent lint, muslin, and linen are used; it is put up in rolls; a piece six and a half yards long and half a yard wide weighs one pound. It is sometimes treated with salicylic and boracic acid. *Water-dressing lint*, which differs from the other in being thicker and more porous, and is used in cases where a water dressing is indicated. *Poultice mass*, a thick, loose-textured lint, one surface of which is covered by a thin film of varnish, and thereby rendered impermeable to moisture. It is used as a substitute for the ordinary poultice by soaking it in hot water and placing it over the affected part.

Waxed paper.—This material was introduced into the Pennsylvania Hospital by Dr. Addinell Hewson. It is prepared by floating tissue-paper for a few seconds on the surface of melted beeswax contained in a broad, shallow pan, and then drawing the sheets between the edge of the pan and a roller, or between the former and the edge of a pine stick, in order to remove the redundant wax. When placed over wet dressings or poultices, it serves to retain their moisture.

Oiled silk, oil-cloth, rubber tissue, and *rubber cloth* are all employed to cover dressings where it is desirable to retain heat and moisture. Under other circumstances, unless the dressings are changed as soon as they become foul, the effect of these water-proof coverings is pernicious. They produce too much warmth, favor the decomposition of discharges, and serve to keep diseased parts bathed with inflammatory products of an irritating or a poisonous nature.

Compresses are formed from muslin, linen, lint, flannel, paper lint, tow, or oakum. They are designed to afford firm support, supply pressure, fill up inequalities, and control bleeding. They are square, oblong, perforated, or graduated, and vary in thickness.

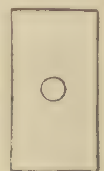
FIG. 469.

Oblong compress.

The square compress is made by folding upon itself a piece of any of the fabrics above named, alternately sidewise and lengthwise, until the requisite size is obtained.

The oblong compress is made either by folding the square once on itself, or by folding the material in one direction and then doubling it in its length. (Fig. 469.)

FIG. 470.



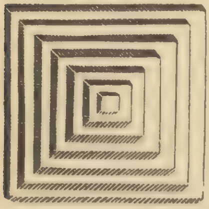
Perforated compress.

The perforated compress differs from the others only in having a hole cut in its centre (Fig. 470), and is designed to relieve pressure by allowing a salient point of the body to rest in the opening.

Graduated compresses are pyramidal, prismatic, and semi-cuneiform.

The pyramidal compress is made by placing a succession of regularly diminishing square compresses upon one another until the pyramid is formed; to keep them from displacement a stitch should be passed through from the apex to the base. (Fig. 471.) This compress is adapted to making concentrated pressure.

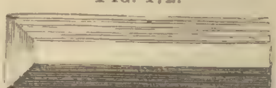
FIG. 471.



Pyramidal compress.

The prismatic compress is made by placing in successive layers a number of oblong compresses, each one more narrow than the preceding. To keep the parts from becoming disarranged, a stitch must be passed through the different strata in the middle and at either end. (Fig. 472.) Such compresses are useful in making concentrated linear pressure, as, for example, over the radial or the ulnar artery.

FIG. 472.

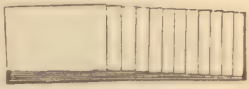


Prismatic compress.

The semi-cuneiform compress, sometimes called the *graduated compress*, is

constructed by placing in superimposed layers a number of oblong compresses, each layer shorter than the preceding one. (Fig. 473.) This compress may be quickly extemporized by reversing a roller upon itself, the reverses being even at one end and successively shorter at the other. Such compresses are used when it is necessary to apply graduated pressure, as in fractures at the lower end of the radius.

Fig. 473.

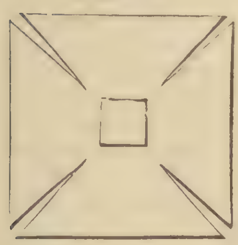


Semi-cuneiform compress.

Retaining compresses constitute a class of surgical appliances which serve to keep in position other dressings or to shield parts against injury. They are the following:

The Maltese cross, which is formed by taking a square piece of muslin or linen and folding it upon itself twice, the first fold making it oblong, and the second square. Thus prepared, one angle will be found to consist of four layers separable from one another. Let this angle be slit down within two or three inches of its centre, and then the piece opened out, when it will be found to have the form shown in Fig. 474.

Fig. 474.



Maltese cross.

The half Maltese cross is prepared by folding a square piece of muslin or linen into an oblong figure, and then slitting down one of the loose angles to within two or three inches of the centre. When opened out it will have the form of Fig. 475. These crosses are much used in amputations, to cover in and keep dressings in contact with the stump. The centre should be placed so as to rest against the end of the stump, and the angles folded smoothly around the surface of the limb.

Fig. 475.

Half Maltese cross.

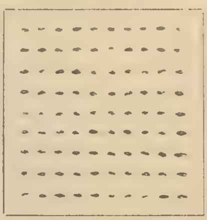
The triangular compress is formed by doubling a large square of muslin or linen diagonally, forming a triangle (Fig. 476); or, if it is desirable to have a single thickness or layer, by slitting diagonally from angle to angle. This forms a very good retaining compress for stumps, or to confine poultices upon the hand. In applying it as a retaining compress, the base of the triangle is placed underneath the limb, the apex hanging free. The latter is then brought up in front of the stump, turned over the upper surface of the limb, and there retained by tying or pinning around the parts the crossed angles of the base.

Fig. 476.

Triangular compress.

The cribriform compress is made by folding a square piece of linen three or four times upon itself, and then cutting out small pieces, or, as it is termed, "slashing the sides." A more uniform and a neater plan is, after folding the square a number of times upon itself, to perforate it at numerous points with a shoemaker's punch. (Fig. 477.) The openings will permit the escape of discharges which flow from a wound or from a suppurating surface.

Fig. 477.



Cribriform compress.

Retractors are linen or muslin strips, designed to hold parts out of the way of injury.

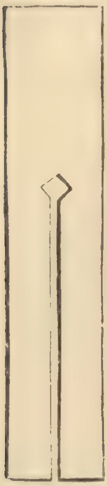
The retractor of two tails is formed by slitting a piece of muslin fourteen inches long and three inches wide one-half of its length, and cutting out a diamond-shaped piece at the termination of the slit, to prevent the extension of the latter. (Fig. 478.)

The retractor of three tails differs from the other in being one inch wider, and in having two slits instead of one. (Fig. 479.)

These retractors are used in amputations to keep the soft parts out of the

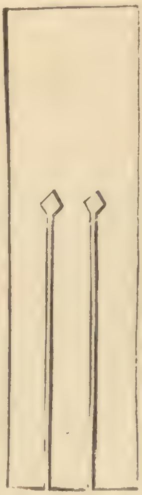
way of the saw. The first is suited to the thigh or the arm, where there is a single bone, one tail passing on either side, after the division of the muscles, after which they are crossed and drawn upwards by an assistant. The second retractor is used in amputations of the leg or of the forearm: the middle tail being carried through the interosseous space, and the lateral ones around the bones, they are collected together and drawn up as in the first instance.

FIG. 478.



Two-tailed retractor.

FIG. 479.



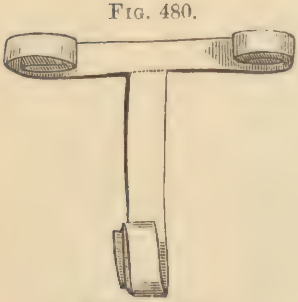
Three-tailed retractor.

There are a number of retaining dressings, which are called T bandages.

The single T bandage, called also crucial, is composed of two parts, a horizontal and a vertical strip of muslin, each two or three inches wide. The vertical is to be sewed to the middle of the horizontal strip. (Fig. 480.) The vertical strip is generally slit for some distance into two tails (Fig. 481), which renders it better suited to the purposes for which the bandage is required, namely, that of retaining dressings to the perineum after operations for fistula of the bowel, or for the support of the bowel against prolapse, or to prevent the protrusion of piles.

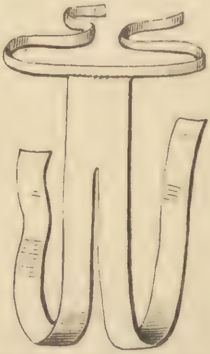
The double T bandage differs from the single one in having two vertical strips separate in their entire length, and sewed to the horizontal band two inches apart, and equidistant from its centre. (Fig. 482.) The bandage is best made from a roller two and a half or three inches wide, the horizontal portion being about two yards and the vertical bands less than a yard long. It is employed for the same purposes as the single T bandage. The different parts of these

FIG. 480.



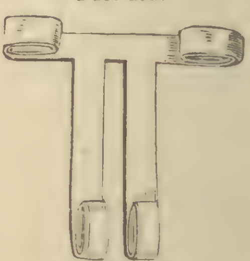
Single T bandage.

FIG. 481.



The incomplete double T bandage.

FIG. 482.



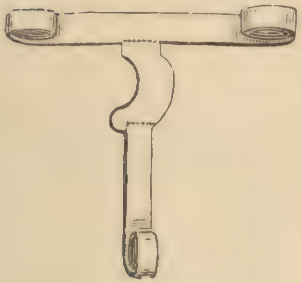
Double T bandage.

dressings should be rolled into cylinders, and each pinned to its corresponding strip, when prepared for future use, as it prevents the bandage from becoming soiled, and maintains the principle of order and neatness. When required for immediate use, it is not necessary to roll the parts up in this manner.

The T bandage of the ear.—This differs from the single T bandage in having an auricular-shaped piece of muslin interposed between the vertical and the horizontal band (Fig. 483), the vertical band being fifteen inches in length and the horizontal one a yard and a half long. The breadth of each need not exceed one inch. The auricular part is sometimes slit in order to allow the ear to pass through. This bandage is an admirable one for keeping a poultice or fomentation to the ear or over the mastoid region.

Application.—The horizontal portions, being rolled, are carried around the head. After making two turns, the vertical strip with its auricular attach-

FIG. 483.



T bandage of the ear.

FIG. 484.

T bandage of the ear applied.

ment is brought down over the ear, or, if slit, on either side, as may be required, then behind and under the jaw, and up to the opposite temple, where it is to be secured by passing over it the horizontal band (Fig. 484), when both are made fast with pins.

The single T bandage of the head consists of a horizontal strip one yard and three-quarters long, and a vertical one fifteen inches in length, each strip being one inch wide. The vertical strip may be made with advantage much wider where it is necessary to cover in a broad surface. This bandage is well adapted to retain a dressing upon a portion of the scalp. (Fig. 485.)

FIG. 485.

T bandage of the head.

Application.—Place the point of junction between the horizontal and the vertical part of the bandage over the middle of the forehead, just above the nose; carry the ends of the horizontal strip around the head, and the vertical strip back to the occiput, where, after being crossed by the former, it should be brought forward to the forehead, and again crossed by the horizontal turns, each strip being secured by three pins.

The double T bandage of the nose may be prepared from a narrow roller or a piece of tape. The two vertical strips should be one yard long, and the horizontal one about two yards, each strip not exceeding three-quarters of an inch in breadth.

Application.—Place the middle of the horizontal strip on the middle of the upper lip, and carry the vertical ones upwards along the sides of the nose to its root, where they are to be crossed and conducted to the back of the neck, and there held by an assistant while the horizontal band is carried back over the sides of the face below the ear to the back of the neck, and crossed over the vertical bands, the ends reversed, and afterwards brought forward above the ears, over the temples and forehead, and there pinned or tied, the other bands being secured in the same way. (Fig. 486.)

The single T bandage of the nose.—This T is sometimes described as a suspensory. It consists of a central part or sheath, to which are attached two pieces of tape, a horizontal and a vertical strip, the former one yard long, and the latter one foot. The centre or sheath is made by folding a piece of muslin into an oblong square, two and three-quarter inches long and two

inches wide, and then cutting it into a triangle with unequal sides, as indicated by the dotted lines BC, CD, Fig. 487.

FIG. 486.

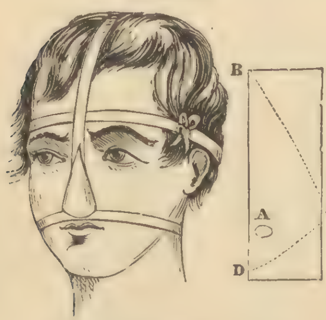
Double T bandage of the nose.

Application.—Apply the shield over the nose, and carry the short tail over the middle of the head to the back of the neck, where it should be held by an assistant; then carry the ends of the horizontal tails across the face to the back of the neck, where they should be crossed over the vertical tail, brought forward, and tied or pinned over one of the temples. The vertical strip is then to be turned upon itself, and made fast with a pin. (Fig. 487.) The sling will answer very well to retain a water or other dressing to the nose.

The double T of the thorax consists of a piece of muslin eight or nine inches wide, and sufficiently long to surround the chest and overlap a few inches. To the middle of the upper border of the horizontal piece is to be attached a strip of muslin two and half or three inches wide, and two feet long. This strip must be slit up into two tails within two inches of its attachment; or two distinct pieces may be sewed a short distance apart to the horizontal band, thus making a double T of the chest.

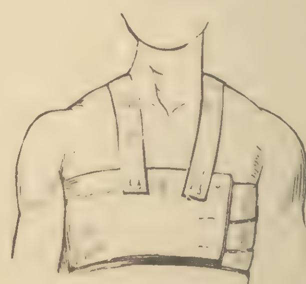
Application.—The broad portion of the bandage is carried around the chest, below the axillæ, and the ends overlapped and pinned. To prevent its slipping

FIG. 487.



Single T bandage of the nose.

FIG. 488.



Double T bandage of the chest.

down, the two ends of the narrow strip are brought over the shoulders, one on either side of the neck, and pinned to the front of the chest portion. (Fig. 488.) This bandage is decidedly superior to all others for retaining dressings upon the chest after excision of the mamma, and is occasionally employed as a dressing for fractured ribs.

The double T of the abdomen consists of a horizontal band eight inches wide, and sufficiently long to encircle the pelvis and overlap, with two vertical bands, twenty inches long and two inches wide, sewed to one of its borders, nine inches apart, and equidistant from the centre.

Application.—The broad or horizontal portion is placed around the pelvis, and the ends overlapped and pinned; the vertical strips are next conducted over the posterior border of the buttocks and the perineum, across the groins, and pinned to the horizontal band in front. (Fig. 489.)

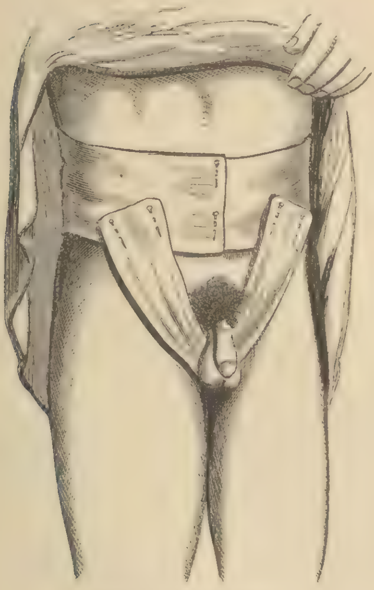
This bandage is principally used to retain dressings upon the surface of

the abdomen, or to exert compression after paracentesis abdominis or the removal of ovarian growths.

The T of the groin consists of a horizontal and a vertical band, each about two yards long and two inches wide, and a triangular piece of muslin eight or ten inches long, and five or six inches wide at the base. The base is to be sewed to the middle of the horizontal band, and the apex to the vertical band.

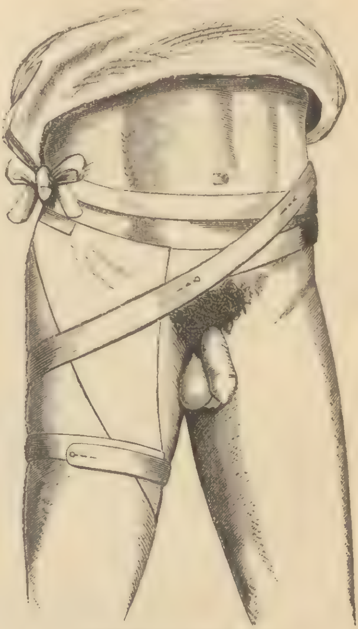
Application.—Place the base of the triangle over the groin, on a line with

FIG. 489.



Double T of the abdomen.

FIG. 490.



Compound T of the groin.

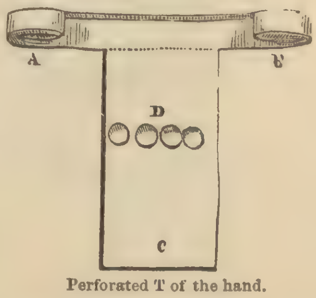
Poupart's ligament, and secure it by carrying the ends of the horizontal band about the pelvis and pinning or tying them together. The triangular piece is next brought down in front of the groin, and made fast by carrying the strip attached to its apex round the posterior and outer surface of the limb, across to the opposite side of the pelvis, and down over the posterior face of the latter, terminating by a circular turn around the thigh. (Fig. 490.)

The T bandage of the buttock does not differ from that of the groin, except in the size of the triangular piece of muslin, which should be nine inches wide at its base, and twelve inches long.

Application.—The base of the triangle is placed above the buttock, and the horizontal band fastened around the body; the apex is next brought across to the inner side of the limb, and retained by the vertical band being carried about the thigh, across the buttock, and pinned to the horizontal part on the opposite side of the body.

This bandage serves to retain dressings to the nates.

FIG. 491.



Perforated T of the hand.

The T bandage of the hand is made by taking a strip of muslin fourteen inches long and one inch wide, and stitching to the middle of one of its borders a piece of muslin five inches wide and ten

inches long, across the middle of which are to be cut four round openings. (Fig. 491.)

Application.—Pass the four fingers through the circular holes in the muslin, folding one part back over the palm, and the other over the back of the hand, and secure these by circular turns of the horizontal band.

This T of the hand forms a very convenient bandage to retain lotions or poultices on the hand.

Slings.

Slings constitute another form of bandages, and are designed to retain dressings to different parts of the head, the face, the arm, and the scrotum. They consist of two parts,—the body and the tails. The body varies both in breadth and in length, and the tails number usually two, four, or six pieces.

The two-tailed sling consists of a single strip of muslin four or five inches wide and one yard long. It is familiar to every one as a simple support of the hand and arm in fractures of the upper extremity.

Application.—The forearm being placed at right angles with the arm, the middle of the body of the sling is passed underneath the wrist, and its ends are carried up in front of the chest and tied or pinned on one side immediately below the clavicle. When tied behind the neck the knot is liable to excoriate the skin.

The four-tailed sling is made by slitting down a piece of muslin at each end, leaving a portion in the centre undivided. (Fig. 492.) The length and breadth of a sling will be determined by its particular application.

Fig. 492.

Four-tailed sling.

When designed for the head, it should be five or six inches wide and thirty-two inches long. Such a sling is well suited to retain dressings upon the back of the neck or on the top of the head.

Application.—Place the body of the sling across the back of the neck, bring the upper tails along the sides of the head immediately above the ears, and after crossing over the forehead, bring them back, and fasten with pins behind the ears. (Fig. 493.)

The four-tailed sling for the top of the head.—Place the body of the sling on the top of the head, bring the posterior tails forward, and secure with a pin or knot beneath the chin; carry the anterior tails back, and fix in a similar way at the back of the head. (Fig. 494.)

Fig. 493.

Four-tailed sling for the back of the neck.

Fig. 494.

Sling for the top of the head.

Galen's bandage, or the six-tailed sling.—This sling is made by slitting into three

tails, to within three inches of its centre, a piece of muslin one yard long and a quarter of a yard wide. The middle strip should be the widest of the three.

In its application the body of the sling is placed on the top of the head, and the middle tails are brought down and tied under the chin. The anterior tails are next carried back to the occiput and crossed, after which the posterior strips are brought forward and made fast by pins. (Fig. 495.)

The four-tailed clavicular sling.—This sling, designed for the treatment of a broken clavicle, requires a piece of muslin seven inches wide and two yards long. The body should be twelve inches in length, and a small conical cut should be made in its centre.

FIG. 495.

Six-tailed sling of the head.

Application.—Place the body of the sling underneath the elbow, so that the olecranon prominence shall settle into the small opening in the centre; bring the lower tails up, one over the front, and the other over the back, of the chest, and secure them with a knot. The upper tails are next to be carried around the body and made fast. This sling forms a very convenient and efficient mode of treating fractures at the acromial end of the clavicle, and answers also as a good temporary support for a fracture near the superior end of the humerus.

The four-tailed sling of the chin.—This sling is made by slitting down at each end, to within two inches of its middle, a piece of muslin forty inches long and three inches wide.

Application.—Place the body of the sling beneath the chin, carry the upper tails across the neck and below the ears, and give them to an assistant. Then carry the lower tails up over the face, in front of the ears, to the top of the head, where they should be crossed, returned to the temporal ridges, and pinned. The upper tails are next taken from the assistant, crossed on the nape of the neck, and brought forward round the head, and above the ears, and, after crossing them, the lower tails at the temples are made to overlap each other on the forehead, where the ends are to be secured with pins. (Fig. 496.)

FIG. 496.

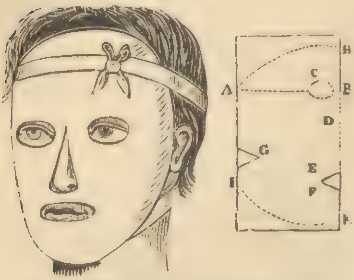
Four-tailed sling of the chin.

This sling is sometimes made of a centre- or chin-piece, slit for two inches at each end, and having four stout pieces of tape one yard long sewed to these short tails. It makes a somewhat neater dressing when prepared in this way. It is chiefly used in fractures and in dislocations of the jaw, or when it is desired to apply a dressing to the chin.

The four-tailed sling or mask of the face.—This consists of a central or facial part and four tapes, two on each side, to hold it in place. To construct the central part or mask, fold a piece of muslin nine inches square upon itself, and round off the

upper and lower free angles, so as to convert it into an ovoidal form; then opening the muslin, draw across from side to side two lines, dividing it into three equal parts. A short distance on each side of the upper line cut out an oval opening for the eyes, make a transverse slit in the middle of the lower line for the mouth, and a vertical slit, commencing a short distance above the last, and extending up to a point midway between the eye-holes, for the nose. The tapes are to be next attached to the upper and lower parts of the sides, the first strip being eighteen inches long, and the last eight or ten inches.

FIG. 497.



Four-tailed sling or mask of the face.

Application.—The body or mask is to be placed over the face so that the eyes, the nose, and the mouth shall correspond to its openings, when it is secured in position by the tails being carried to the back of the neck and behind the head, the last strip being crossed, brought forward, and tied over the forehead. (Fig. 497.) This forms an excellent method of retaining dressings to the face, such as are frequently required after burns, scalds, etc. I have often used this mask with great benefit as a means of applying a water dressing to the face in bad cases of acne. In order to retain the moisture, I have the mask made of patent lint, and direct that a piece of oiled silk of a similar form shall be basted on its outer surface.

FIG. 498.

Four-tailed sling of the breast.

The four-tailed sling of the breast is prepared by taking a piece of muslin from six to eight inches square, cutting out a V-shaped piece from each of the four angles, two and a half to three inches in depth, and then stitching the sides together, thus giving the square a concave form. To each corner sew a broad piece of tape one foot and a half in length. Another method, but a less perfect one, is to cut four slits, one or two inches deep, in the middle of the four sides, and attach the tapes to the angles.

Application.—Raising the breast, place over it the body of the sling, tying the upper tails or tapes behind the neck, and the lower ones about the body. (Fig. 498.) This is a valuable support to the breast, and will be found quite useful in applying pressure or retaining dressings, such as lotions, poultices, etc.

The Roller Bandage.

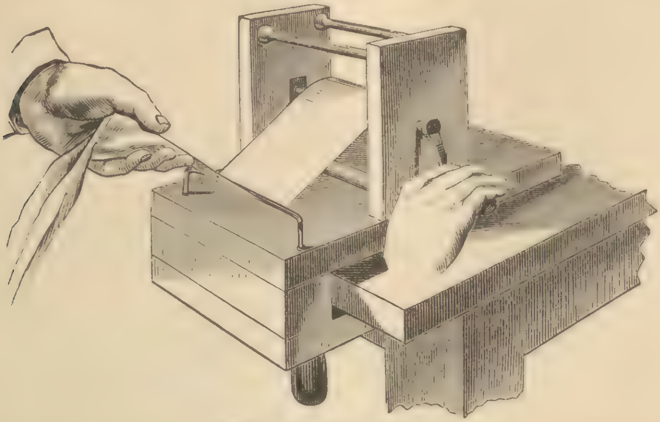
The roller is a bandage made from muslin, linen, calico, silk, or flannel. The material which answers the best purpose is unbleached muslin. When torn into a strip and rolled into a cylinder it is called a *roller*. Although the roller is often made by sewing strips together, yet for general use it should consist of a single piece. These strips vary in length and in breadth, ranging from two to ten yards in length, and from three-quarters of an inch to three inches in width.

In order to form the cylinder, it may be rolled by the hands, or, more expeditiously, by means of a machine called the roller. This simple contrivance is an indispensable appointment for hospitals and for rooms appropriated to

practical surgery. It can be screwed to the edge or end of a table when needed for use.

In using the machine, one end of the strip of muslin designed for a roller is wrapped around the spindle, which is turned with one hand, while with the

Fig. 499.



Machine for rolling bandages.

other the piece is guided evenly under a rod of metal, which extends between the two sides of the machine. (Fig. 499.) When the piece is wound up, the mass must be grasped by the hand, when, reversing the spindle, the latter can be drawn from the centre of the roller. The ravelings which adhere to the ends of the latter must now be pulled off.

Fig. 500.

Forming a roller bandage by the hands.

When the roller is formed by the hands, one end of the strip should be doubled upon itself to the extent of three inches, and this again repeated two or three times, in order to form a little mass or nucleus, or the end may be rolled into a little cylinder with the fingers, and afterwards between the palm of the hand and the thigh, until it has attained some little bulk, when it should be held by its ends between the thumb and index finger, or the index and middle fingers, the unwound portion of the strip being supported between the radial border of the ring-finger and the thumb. By imparting simultaneously the movement of pronation and supination to the two hands, the strip can be wound up with great facility. Every student should practice this manipulation, changing the mass of the roller from one hand to the other until either can be used indifferently. (Fig. 500.)

Kinds of rollers.—There are two kinds of rollers,—the *single* (Fig. 501) and the *double* (Fig. 502).

Fig. 501.

Single roller.

Fig. 502.

Double roller.

The parts of the single roller are its *extremities*, *body*, *surfaces*, and *borders*.

There are two extremities,—the *initial*, which is the free end, and the *terminal*, which is the one in the centre of the cylinder. The *body* is the mass between the two extremities. The surfaces are two in number, the external and the internal;

and the *borders* are designated upper and lower, according as they are towards the proximal or the distal part of the limb.

The double roller, in consequence of its being rolled from each end of the strip, differs from the single roller in having two bodies and no initial end.

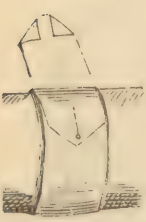
The double roller might, without inconvenience, be expunged from the list of surgical dressings.

Rollers are designated by different names, according to their direction or to the particular end had in view in their application. Those varieties which take their names from the course or direction of the bandage are called *circular*, *spiral*, *oblique*, *spiral reversed*, *recurrent*, *figure-of-eight*, and *spica*. Those named from the effect produced are called *uniting*, *dividing*, *expelling*, and *compressing* rollers.

Before describing the most useful of these bandages, I may remark that the ability to apply a roller, or, indeed, any surgical dressing, properly, is a very high qualification, and one which can be attained only by practice. No man is competent to give proper attention to a patient who is the subject of injuries demanding surgical care, unless he can apply a roller with precision and neatness. I am quite sure that on the use of the roller not unfrequently depends the success or the failure of the young physician just entering upon the duties of his profession. People generally are not unobservant spectators of the deportment of medical men, and of the skill which they may display in the use of technical resources. Too much credit cannot be awarded to those gentlemen who have for a number of years been engaged in conducting private courses upon practical surgery, the fruit of which labor I see in almost every professional excursion which I make through this and the adjoining States.

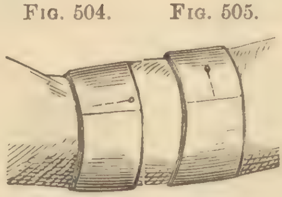
General directions for applying a roller.—1. The body of the roller should be held in one hand by its ends between the thumb and two or three of the

FIG. 503.



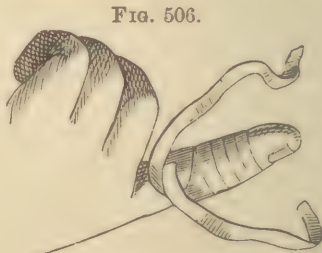
The corners turned in and pinned.

FIG. 504. FIG. 505.



Longitudinal and transverse introduction of the pin, the ends of the roller having been previously turned in.

FIG. 506.



Securing the roller by a knot.

fingers, or in the palm of the hand. The external surface of the initial end should be laid upon the part to which it is to be applied, and fixed with the finger or the thumb of the other hand until the body is conducted round the limb, when the hands should exchange offices as the roller is passed from one to the other. These movements are repeated two or three times, one turn accurately covering the other in order to secure the initial end, after which the remaining part of the bandage is applied according to the required indications, and made fast either by turning in its angles or by folding the terminal end upon itself (Fig. 503), and then inserting one or more pins, either longitudinally or transversely, with their points buried out of sight. (Figs. 504, 505.) If the pins be used in a longitudinal direction, the heads should point towards the proximal end of the limb; if transversely, they should look outwards.

Another plan often employed to secure the terminal end is to slit it up a short distance and tie the extremities into a knot. (Fig. 506.)

2. The roller, except in a few instances, should always commence at the

distal extremity of the limb, the first turn being made at the wrist in the case of the upper extremity, and at the ankle in the lower extremity, then passing to the hand or the foot, and subsequently ascending the limb.

3. The roller must be applied smoothly, with uniform, equal, or even pressure. A neglect of this precept, making it tight at one place and loose at another, will produce œdematous swellings, and may cause gangrene.

4. A roller should be removed and reapplied whenever it becomes disarranged or loose, or in case of subsequent swelling making it too tight. The sensations of the patient should receive due consideration. When the bandage is felt to be too tight, it should be immediately relaxed.

5. In removing a roller, after the terminal end has been unloosed it should be unwound in a direction the reverse of that which was used in its application, and as the unrolled bandage is passed from hand to hand, the loose turns should be gathered carefully together into a mass, so that they may not become entangled about the part and give rise to pain or to disarrangement of the limb.

Special Rollers.

The circular roller.—This roller is very simple, and consists in causing one turn to overlap accurately the preceding one. (Fig. 507.)

Use.—Its application is limited to retaining a dressing to the eyes, the temple, the forehead, or the neck.

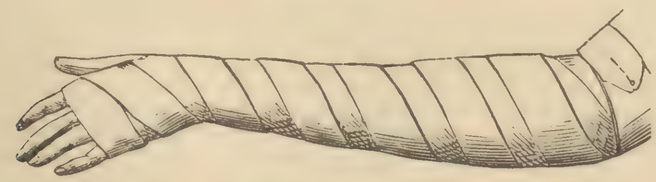
The oblique roller.—In this bandage the roller is made to ascend the limb in a direction so oblique as to leave intervals between the consecutive turns. (Fig. 508.)

Use.—Its chief value is to retain dressings to a part where pressure is a matter of secondary importance.

Fig. 507.

Circular roller of the neck.

Fig. 508.

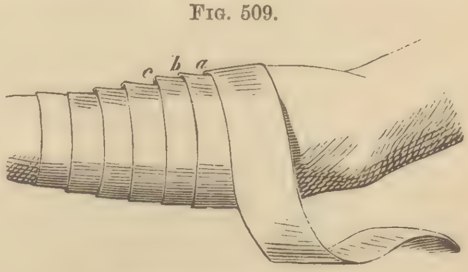


Oblique roller of the arm.

The spiral roller.—This roller ascends the limb in a spiral manner, each turn overlapping the preceding one about one-third. (Fig. 509.) This bandage answers every purpose when applied to parts of uniform dimensions; but, as the arm or leg increases in circumference, it is impossible for a spiral roller to press with equal and uniform force upon all parts of the surface. (See *a*, *b*, *c*, Fig. 509.) To remedy this defect the bandage is subjected to a reverse by which it can be applied evenly to the inequalities of a part.

Spiral reversed.—The peculiarity of this roller is the reverse given to its turns, which makes it the most useful of all roller bandages. Simple as this little manœuvre of making a *reverse* appears, there are persons who never

Fig. 509.

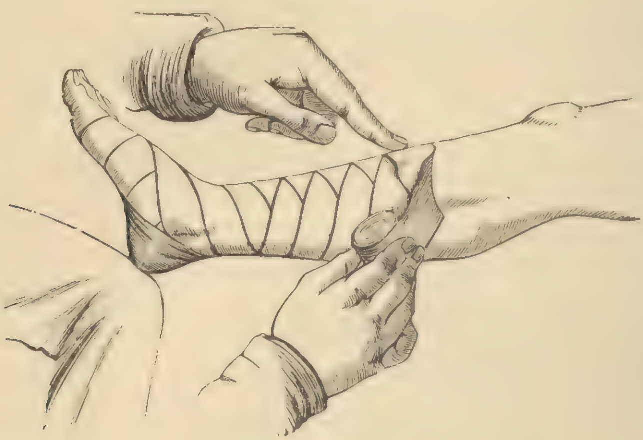


Spiral roller applied to the arm.

acquire any facility in forming it. Attention to the following details will tend very much to simplify its execution.

After laying down the initial end of the roller, and making it fast by two or three circular turns, change the direction of the bandage to that of a spiral, and, preparatory to making the reverse, place a finger upon the upper edge of the roller so as to keep it in contact with the limb; then, unrolling the bandage three or four inches, carry the body of the roller towards the limb, so as to allow the strip to remain quite slack, and then, by a motion of the wrist, turn the hand from supination to pronation, when the reverse will be smoothly formed. (Fig. 510.) These reverses should be made

FIG. 510.



Making the spiral reverse.

in the same line, and never over a salient portion of the skeleton if it can possibly be avoided.

Spiral reversed of the upper extremity.—This roller should be two and a half inches wide and seven or eight yards long. The initial end being first fixed by a few circular turns around the wrist, the roller is carried obliquely across the back of the hand over the palm to the ends of the fingers, and then made to ascend by spirals to the junction between the thumb and the index finger. A few figure-of-eight turns are next made in order to cover in the root of the thumb together with the carpal portion of the hand, after which the roller is conducted by spiral reverses to the elbow. The elbow is covered in either by reverses, by spirals, or by figure-of-eight turns, always observing first to flex the arm moderately, provided that position is afterwards to be maintained. From the elbow the roller is continued up to the shoulder, where it is fastened with a pin. (Fig. 511.) This bandage is a matter of daily application, and should be practiced by the student with great care, in order that he may be able to apply it with just the proper degree of pressure, regularity, and neatness. It is frequently applied in fractures at and above the elbow; it is used after operations, and often in cases of œdematous swellings of the arm and the leg.

The spiral reversed of the finger.—This roller should be three-quarters of an inch or an inch wide and about a yard long.

In its application two or three circular turns about the wrist are first made to fix the initial end of the roller; it is then carried obliquely across the back of the hand and to the front of the finger, after which the spiral reverses are made up to the metacarpo-phalangeal joint, when it is completed by two circulars of the wrist, and the end slit into two slips and tied around the joint.

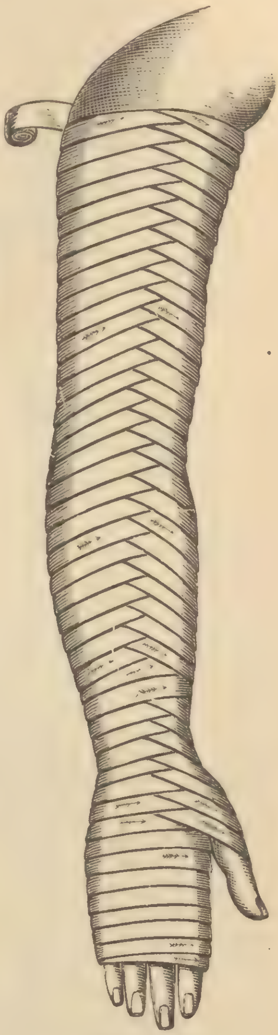
The spiral reversed of the four fingers.—The roller for this purpose should be seven yards long, and of the same width as the preceding one.

To apply it, first make the usual circulars around the wrist, cross over the back of the hand to the first interdigital cleft, and by oblique turns to the extremity of the first or index finger; then return by spiral reverses to its junction with the metacarpal bone, and pass to the second or middle finger, descending to its extremity by obliques, and back to its root by reversed turns, and so in succession until all the fingers are covered in; then finish by spiral turns around the metacarpal, carpal, and wrist bones. (Fig. 512.)

The spiral reversed is frequently applied to a single finger in cases of wounds or of fracture, but to all the fingers very rarely.

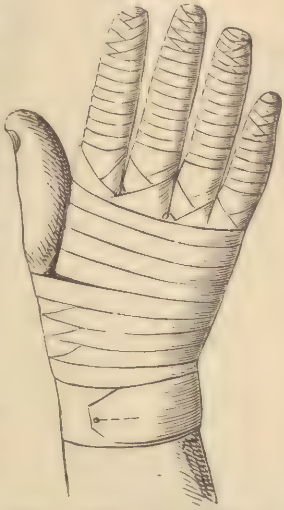
The spiral reversed of the penis.—This bandage should be three-quarters of an inch wide and twenty inches long. To apply this roller, draw the penis forward and make two or three circulars close to the pubes; then by an oblique turn pass to the glans, and return to its root by spiral reverses, slitting up the terminal end and tying the strips around the organ. (Fig. 513.) This bandage is not secure, and though occasionally employed to retain dressings after operations for phimosis, or to compress the urethra over a bougie in case of hemorrhage after operation upon that canal, yet it is unsatisfactory, and might well be erased from the list of dressings.

FIG. 511.



Spiral reversed of the upper extremity applied.

FIG. 512.



Spiral reversed of the four fingers.

FIG. 513.

Spiral reversed of the penis.

Spiral of the hand, or demi-gauntlet.—This bandage requires a roller one inch wide and seven yards long. After a few circular turns of the wrist are first made, the roller is carried obliquely across the back of the hand or across its palm, according to the direction in which it runs, passing round the root of the little finger, and back to the wrist. Around the latter a single circular turn is made, and from thence the bandage is carried to the ring finger, and again to the wrist, and so by similar turns until all the fingers and the thumb have been included, when the terminal end should be secured at the wrist. (Fig. 514.)

This bandage is used to confine dressings of various kinds to the back

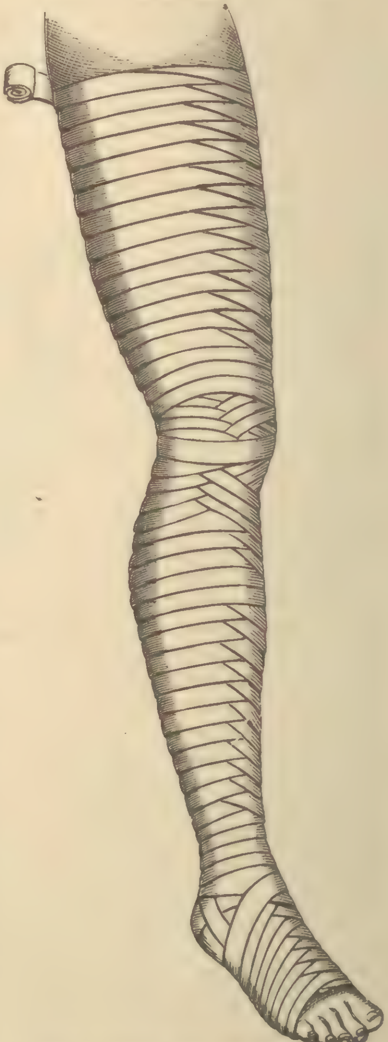
of the hand or to its palmar surface, but, though very secure, is not generally used by dressers.

The spiral reversed of the lower extremity.—This is an indispensable dressing,

Fig. 514.

Spiral of the hand, or demi-gauntlet.

Fig. 515.



Spiral reversed of the lower extremity.

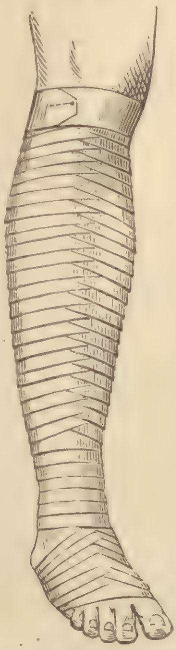
and should be studied with great care. It requires two rollers, each two and a half inches wide and seven yards long, as a single roller fourteen yards in length is too bulky to be properly handled.

In applying this roller, the patient and operator may be seated opposite to each other, the heel of the former resting on the knee of the latter, or, what is better, the limb may be supported by an assistant, the patient either sitting or lying. The surgeon, taking one of the rollers, makes a few circular turns around the ankle, above the malleoli, then crosses obliquely over the dorsum of the foot to its outer or inner side, according to the hand used in holding the roller, passing next under the sole of the foot to the metatarso-phalangeal joint of the little or great toe; the bandage is now made to cover in the foot by successive spirals, embrace the ankle with a figure-of-eight, and ascend the limb by spiral reverses to the knee, where the first roller will terminate. The second roller is next taken, and by one or two circular turns fixes the terminal end of the first, after which it is conducted up the limb, covering the knee either by spiral reverses or by figure-of-eight turns, the remaining portion of the bandage being exhausted upon the thigh. (Fig. 515.)

The French spiral reversed commences at the metatarso-phalangeal articulation and covers the foot with reverses to the front of the ankle, then passes from the latter to the leg, which is inclosed as in the ordinary spiral previously described. (Fig. 516.) It is not so secure a bandage as the first, since the turns of the foot are liable to become displaced.

In neither of the bandages described are the heel, or the tips of the toes, included; the dense tissue of the former, and the close adhesion of its skin to the subjacent parts, render this unnecessary, and the exposure of a portion of the toes enables the surgeon to determine by their color and temperature the condition of the circulation.

Fig. 516.

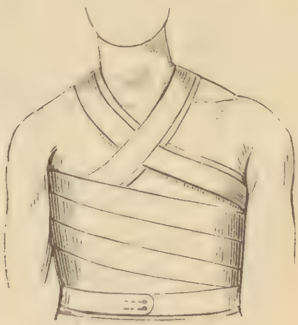


French spiral reversed.

Fig. 517.

Heel covered with spiral reversed roller.

Fig. 518.



Spiral of the chest.

Should it be desirable at any time to cover the heel, it can be done as follows: after commencing by the usual spiral reversed, and having reached the instep, conduct the bandage over the point of the heel, up in front of the ankle, down under the heel, and around to the opposite side, and again in front of the ankle, under the heel, and round its surface to the front of the joint, after which it should be continued up the limb. (Fig. 517.) The spiral reversed rollers are constantly employed in fractures, ulcers, etc.

Spiral of the chest.—A roller three inches wide and ten yards long is required for this dressing. Two or three circulars around the waist are to be first formed, the patient being in the sitting posture, and then the roller is made to ascend in spirals, each turn covering one-third of the preceding one until the axillæ are reached, when the terminal end should be brought over the shoulder and pinned in front (Fig. 518) to the turns on the front of the chest or round the neck, and then attached to the spirals. This bandage is sometimes used in cases of fractured ribs, and also to retain dressings after the removal of the female mamma.

Spica Bandages.

These form a useful class of bandages. They take their name from the resemblance which they bear to the leaves of an ear of corn. They are divided into *single* and *double* and into *ascending* and *descending* spicas.

The spica of the shoulder.—When the successive turns pass from the shoulder to the neck, they constitute the ascending spica; when from the neck to the shoulder, the descending spica. The roller should be two and a half inches wide and eight yards long. In its application, make first two circulars at the upper part of the arm; then, if the roller is running from without inward, carry it obliquely across the front of the upper part of the chest, through the axilla of the opposite side and across the back to the place of commencement; then, passing under the arm of the same side, form the spica over the outer part of the neck or the shoulder, according as the descending or ascending bandage is contemplated. These turns are to be repeated—each turn overlapping the preceding about one-third—until the roller is nearly exhausted, when its terminal end, being carried round the back of the neck and down the front of the chest, should be pinned. (Fig. 519.)

This spica will be found a useful termination of the roller employed in securing splints to the arm in fractures at the upper part of the humerus: also well suited to confine dressings to the shoulder. Between the borders of the axilla and the roller a little cotton should be interposed to prevent excoriation.

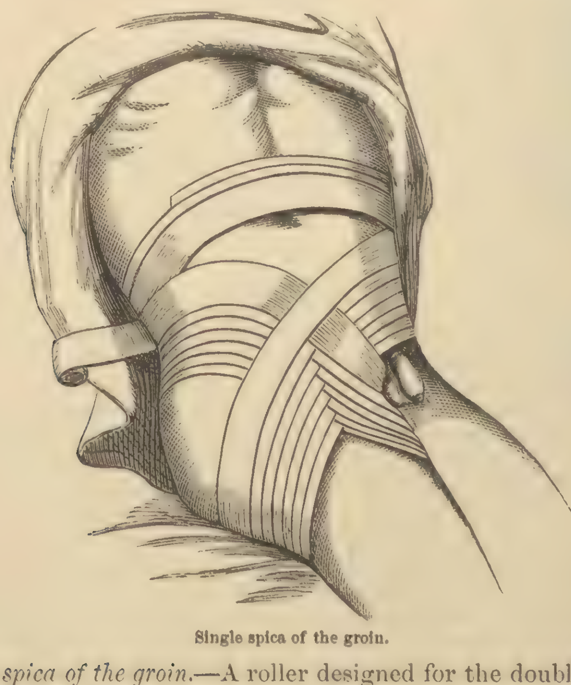
FIG. 519.

Spica of the shoulder.

The spica of the groin.—This dressing requires a roller two inches and a half to three inches wide and ten yards long. The initial end of the roller is made fast by two or three circulars of the thigh, or the same number around the body above the crest of the ilia. If the bandage is commenced at the upper part of the thigh, it should, after these primary circulars, be conducted up in front of the groin, obliquely across the outer side of the pelvis or lower part of the abdomen, according as it is designed to be an ascending or a descending spica, then round the posterior part of the body and the corresponding part of the opposite side down in front, underneath, and up over the inside of the thigh. These turns are to be repeated until the roller is exhausted. In this, as in the spica of the shoulder, each turn overlaps the preceding one about one-third. (Fig. 520.)

This spica is admirably suited to make compression over the groin, as in cases of enlarged glands or after operations for hernia.

FIG. 520.

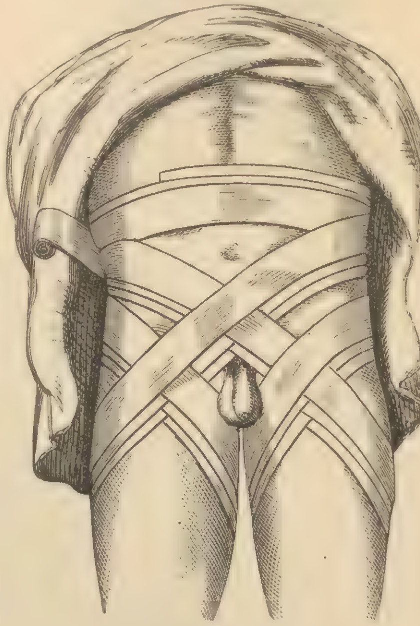


Single spica of the groin.

The double spica of the groin.—A roller designed for the double spica should be two and a half inches wide and twelve yards long; or two rollers each six yards in length may be used.

After making two circular turns around the pelvis from right to left, and on reaching the left groin, the roller should be carried obliquely downwards over the outer side of the same thigh and brought up along its inside in such a manner as to cross over the descending turn; next, it should be carried round the posterior surface of the pelvis to the right groin, and, passing down over the inner surface of this thigh, should be conducted up along its outer side, and from thence carried round the front of the pelvis to the left side. These turns may be repeated, and the dressing finished by two or three circulars of the pelvis. (Fig. 521.) This bandage may be used in cases requiring pressure over both groins.

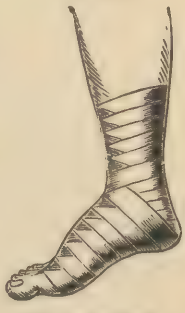
Fig. 521.



Double spica of the groin.

The spica of the foot.—This bandage, sometimes called the bandage of Ribbail, requires a roller two inches wide and seven yards long. In its application, the simplest plan is to make two circular turns around the metatarso-phalangeal articulation, and two spirals over the metatarsus to the instep; then carry the roller about the point of the heel, allowing its lower edge to project well towards the sole of the foot; from thence carry it along or parallel with the outer or the inner side of the foot as the case may be, and cross over the tarsal extremity of the metatarsal portion of the foot under the sole and back to the instep, where the spica is to be formed. From this point the roller passes again round the heel a little higher up, overlapping a part of the previous turn, and again along the side of the foot to the instep, beneath the foot and back to the instep, making a second spica, and again back to the heel, and so continues forming one after another in the ascending order until the foot and heel are entirely covered, when the remaining part of the roller can be finished by spiral reversed turns upon the leg. (Fig. 522.) This bandage, while it is very beautiful and artistic, really possesses no superiority over the ordinary spiral reversed of the lower extremity.

Fig. 522.



Spica of the foot.

The spica of the thumb requires a roller three-fourths of an inch wide and three yards long. Fix the initial end of the roller by three circular turns around the wrist. On completing the third turn, carry the roller between the index finger and the thumb, passing round the latter to its inner side; from thence across its metatarsal bone to the wrist; around the wrist back again to its outer side, as in the first instance, repeating in a similar manner these turns, forming the spicas over its radial border, each turn overlapping two-thirds of the preceding one, and finally terminate the roller at the wrist. (Fig. 523.) This roller may be used to secure a dressing after excision of the metacarpal bone of the thumb, or in cases of luxation to give security after a reduction of the metacarpo-phalangeal articulation.

Figure-of-eight bandages.—These form a useful class of bandages, and take their name from the fact that the turns, when complete, resemble the figure eight. The bandage is much employed about articulations; and in the ordi-

nary spiral reversed of either the upper or lower extremity, many prefer it as best suited to cover in the joints,—as the ankle, the knee, the wrist, and the elbow.

The figure-of-eight of the elbow requires a roller two or two and a half inches wide and two yards long. Place the initial end on the outer side of the forearm a short distance below the elbow-joint, and, after fixing it in position with a finger, carry the roller obliquely upwards across the front of the joint above the internal condyle, round the inner and posterior surfaces of the arm to a point above the external condyle, then obliquely downwards over the front of the joint, where it should intersect the first portion of the bandage, finally pass to the inner and posterior surfaces of the forearm and to the point of beginning, where it may be secured, or the turns may be repeated two or three times, and before making them fast a circular may be made around the joint, the arm being at the same time slightly flexed. (Fig. 524.) This bandage was quite common at a time when the practice of physicians was more sanguinary than it is at present; a strip of ribbon took the place of the roller, and the two ends were tied in a knot directly over the bend of the arm.

Fig. 523.

Spica of the thumb.

Fig. 524.

Figure-of-eight of the elbow-joint.

The figure-of-eight of the chest.—There are two figure-of-eight bandages of the chest, viz., the *anterior* and the *posterior*. They are sometimes described as the anterior and the posterior *crossed of the chest.*

Each requires a roller two and a half inches wide and seven yards long; and in both the patient should be in the sitting posture when the bandage is applied.

The anterior eight.—The surgeon, standing in front of the patient, first makes two or three circular turns at the upper part of the arm, followed by the same number of reverses, thus making the initial end of the roller secure. Drawing next the shoulders well forward, the roller must be carried over the shoulder above the articulation, and obliquely downwards across the front of the chest and through the axilla of the opposite side. From thence the roller is made to ascend upwards, behind and over the shoulder, and forwards and downwards over the chest to the place of commencement. These turns are to be repeated, each overlapping the preceding one about two-thirds of its breadth, and ascending or descending according to the pleasure of the operator, until the bandage is exhausted. The margin of the axilla should be protected against undue pressure from the roller by interposing some cotton between the latter and the skin. (Fig. 525.) This bandage is used to approximate wounds on the front of the chest, attended with loss of substance.

The posterior eight.—This differs from the preceding one by the intersections being made on the back instead of on the front of the chest. The surgeon, standing behind the patient, makes two or three circular turns and as many reversed turns of the roller from within outwards around the upper part of the arm, and drawing the shoulders backwards secures them in this position by successive turns around the axillæ and shoulders of the two sides. (Fig. 526.) The same care should be observed as in the former bandage to

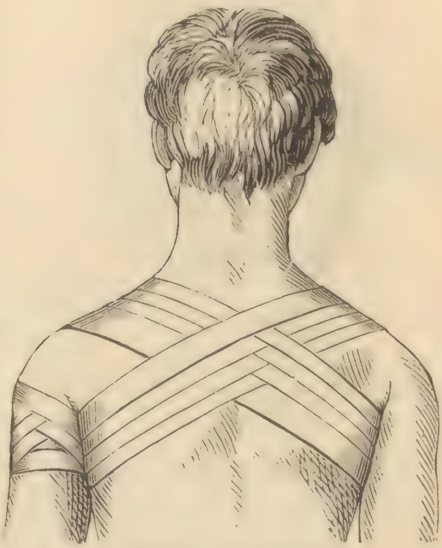
protect the margins of the axillæ from undue pressure by the use of cotton. This bandage will serve to approximate wounds which gape on the back of the trunk, or may be used in certain fractures of the clavicle.

The figure-of-eight of the neck and the axilla.—The roller required for this

FIG. 525.

Anterior eight of the chest.

FIG. 526.



Posterior eight of the chest.

bandage should be two inches wide and four or five yards long. Fix the initial end of the roller by making two circular turns of the neck, then carry the roller either in front of or behind the shoulder—according to the direction given to the bandage—through the axilla, and then round the neck, passing from one to the other until the bandage is exhausted. (Fig. 527.)

FIG. 527.

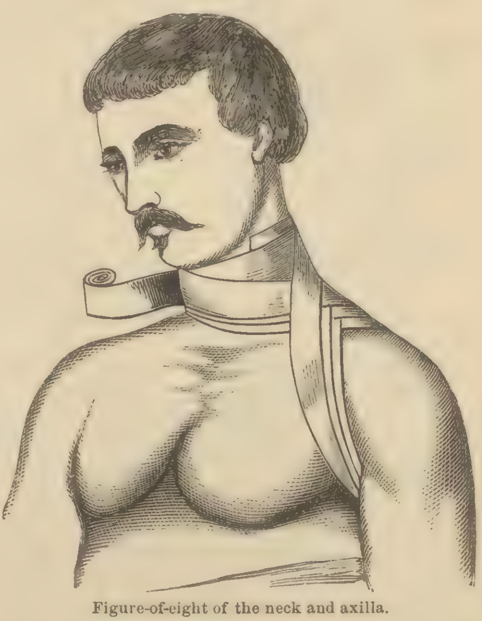


Figure-of-eight of the neck and axilla.

This bandage will serve to secure a dressing to the side of the neck above the shoulder.

Figure-of-eight of the eye.—The roller for this bandage should be two inches wide and five yards long.

First make two or three circulars of the forehead and the occiput, always in a direction from the eye to be covered. After reaching the back of the head with the third turn, carry the roller down under the occiput and up over the face, the affected eye, the root of the nose, and across the opposite temporal ridge, repeating these turns three or four times, and terminating by a circular as at the commencement. This bandage is some-

times termed the crossed of the eye. (Fig. 528.) It will answer to retain dressings to the eye or eyebrows after operations, especially where compression is required.

The double figure-of-eight of both eyes.—The roller for this bandage should be two inches wide and eight yards long.

Fig. 528.

Figure-of-eight of one eye.

Make two circular turns of the head, and, on completing the second, carry the roller to the back of the neck, under the ear, and up across the face, over the eye and the root of the nose, to the temporal eminences of the opposite side, and from thence down to the back of the neck. These turns should be repeated two or three times, after which, on completing the last one, and reaching the parietal eminences, the roller should be carried round the forehead, obliquely across the root of the nose, the eye, and the cheek of the opposite side, repeating these turns three times and terminating by circular turns around the forehead and the occiput.

Figure-of-eight of the jaw and the head.—This is sometimes called Barton's bandage. It requires a roller two inches wide and five or six yards long. The initial end is placed below and to one side of the occipital protuberance, where it is held by a finger, while the roller is carried obliquely across the head, a little in advance of the parietal protuberance, to the opposite temple; from thence down the side of the face, in front of the ear, beneath the jaw, and up over the corresponding portions of the face and temple of the opposite side. At the junction of the coronal and sagittal sutures two turns of the bandage now intersect; then it should descend in front of the parietal and below the occipital protuberance, on one side of which it should cross the initial end of the bandage, and be conducted forward beneath the ear and around the jaw to the place of beginning. The subsequent turns are made in the same order as the first. (Fig. 529.) A pin should be inserted at the different points of intersection.

Fig. 529.

Figure-of-eight of the jaw and head, or Barton's bandage.

For fractures of the jaw and luxations, as well as to retain various surgical dressings, this bandage is of the greatest value.

There are certain other bandages applicable to the head which do not strictly belong to any of the classes named, and which may very properly be introduced in this place.

Gibson's bandage.—This dressing requires a roller two inches wide and six yards long. The initial end of the roller is placed over the temple of one side and fixed with a finger, while the roller is carried over the junction of the coronal and sagittal sutures to the opposite temple, down in front of the ear, over the side of the face, under the jaw, and upwards over the opposite side of the face to the place of beginning. Repeat these turns three times, then reverse the roller and pass round the head above the ears three times. In making the third of these turns, instead of bringing the roller above the ear at the place of beginning, carry it below, and round the base of the jaw and chin to the back of the neck. Three of these turns should be made, and the bandage terminated by reversing it behind the occipital protuberance and bringing it forward over the vertex. (Fig. 530.) Pins, as in

Barton's bandage, should be inserted at the different points of intersection. The simplest manner of remembering the turns of this roller is to view it as consisting of three vertico-mental, three occipito-frontal, and three

FIG. 530.

Gibson's bandage.

FIG. 531.

Occipito-facial roller.

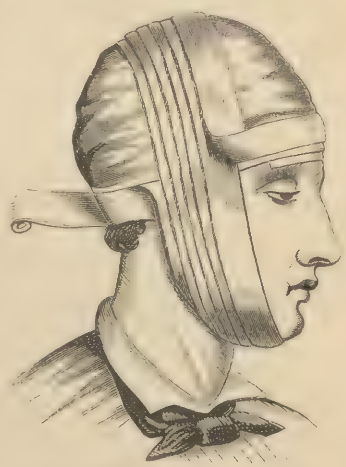
cervico-mental turns. It is a very solid bandage when properly applied, and answers the same object as that of Barton.

The occipito-facial bandage requires a roller four yards long and two and a half inches wide. The initial end of the bandage being placed over the temple on one side, the roller should be carried up over the vertex, down over the temple and side of the face, under the chin, and up on the opposite side to the point of beginning. These turns should be repeated a number of times, and the roller terminated by reversing its course and conducting it round the back of the head from one temple to the other, over both of which the bandage must be pinned. (Fig. 531.)

This roller can be employed with advantage in dressing wounds over the parotid region or on the side of the face.

The crossed or oblique of the angle of the jaw.—This requires a roller two inches wide and five yards long. Apply the initial end of the roller upon the temple and fix it by two or three circular turns around the head, from right to left if the left angle is to be acted upon, and from left to right if the other angle is to be treated. On bringing the roller to the back of the head, on the third turn conduct it over the nape of the neck, behind the ear of the sound side, beneath the jaw to its angle on the injured side, and from thence up over the face, the temple, and obliquely across the head, down behind the ear of the sound side, repeating these obliques, and ending by making a circular of the cranium. (Fig. 532.) This bandage is used occasionally for fractures of the neck and ramus of the jaw, in which case a compress should be interposed between the angle of the injured side and the roller.

FIG. 532.



Crossed bandage for the angle of the jaw.

The V bandage of the head and jaw.—This requires a roller two inches wide and five yards long. Make two or three circulars of the vault of the cranium. In forming the last, instead of passing round above the ear, bring the roller down below the auricle and around the

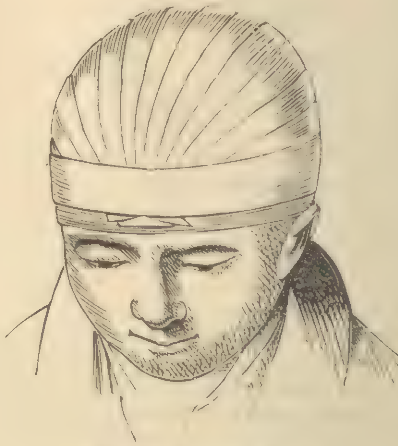
jaw; after repeating this last turn, alternate the turns of the head and jaw. (Fig. 533.) In extensive operations upon the lips, or after the removal of tumors of the neck below the ear, this dressing is valuable. This bandage was devised by Dr. Hunter.

The recurrent bandage of the head.—The roller for this bandage should be two inches wide and five yards long. Make two or three circular turns of the vault of the cranium, and, on reaching the middle of the forehead,

FIG. 533.

V bandage of the head and jaw.

FIG. 534.



Recurrent bandage of the head.

at the root of the nose, reverse the roller, fixing the reverse with a finger, and carry it back over the head parallel with the sagittal suture to a point below the occipital protuberance, where it should be retained by an assistant, while the roller is again reversed and brought forward to the forehead, overlapping the outer two-thirds of the preceding strip. These recurrents should be repeated until one side of the head is covered, when the other must be similarly treated, observing to make all the recurrents converge near the root of the nose and below the tuberosity of the occipital bone, where they can be held underneath the thumb of the surgeon and the fingers of an assistant, after which one or two circulars of the vault of the cranium will fix them securely in place. (Fig. 534.) This bandage is designed to retain a dressing to the head.

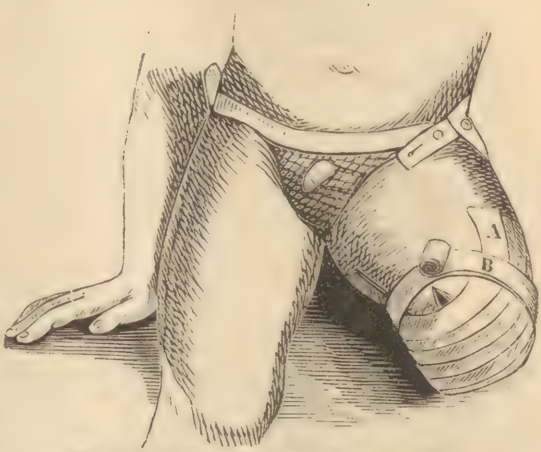
The recurrent bandage for amputations.—This requires a roller two and a half inches wide and six or seven yards long for the thigh, and for the leg and the arm one or two inches wide and five yards long. In its application, a few circular turns are made four inches above the end of the stump, after which the roller is reversed on the middle of the front of the limb, carried over the centre of the stump, and back over the under surface of the limb to a point opposite the one where it commenced in front. These recurrents are to be repeated, covering first one-half of the stump, and then the other half, and all converging to a point in front and another behind the limb, where they can be commanded by the fingers of the surgeon and an assistant, or, if the size of the limb will allow, both may be grasped by the thumb and fingers of the surgeon, after which a few circulars will secure all in position. (Fig. 535.) This bandage is constantly in use to retain dressings applied after amputation.

The unilateral suspensory and compressor of the breast.—This roller should be two or two and a half inches wide and eight yards long.

In its application, the patient must be in the sitting position in bed or on a stool, and the surgeon stands on the side to be dressed. Place the initial end of the roller behind and below the posterior border of the axilla of the

affected side, carry the roller across the back to the opposite shoulder, over the latter, obliquely down over the front of the chest, and underneath the breast to the axilla of the affected side, from thence across the initial end of the roller, and repeat these turns two or three times, after which form a circular of the body, and continue alternating circulars and obliques, each turn as it ascends covering in the preceding one about a third. (Fig. 536.) Thus applied, the bandage serves to support, to suspend, and to compress the breast. The successive turns, both oblique and circular, should be repeated until the gland is covered in. This bandage may be used to apply pressure to tumors of the mammary gland, or in cases of mammary abscess to prevent the formation of sinuses.

Fig. 535.



Recurrent dressing after amputation of the thigh.

The bilateral suspensory and compressor of the breasts.—This bandage can be made with a roller ten or twelve yards long and two and a half inches wide, or with two rollers each six yards in length. If a single one be used, the initial end should be placed over the posterior border of the right axilla, and the cylinder carried obliquely across the back and over the left shoulder; from thence the roller must be continued in front of the chest, under the right breast, and back to the point of beginning. After making two or

Fig. 536.

Single suspensory and compressor bandage of the breast. The circular turns should be made over the one breast and under the other.

Fig. 537.

Bilateral suspensory and compressor of the breasts.

three of these cervico-axillary obliques, the roller should be carried across the back to the left side, and the same number of turns made as on the right. After this the turns should alternate on the two sides, and the dressing should be be completed by making horizontal circulars of the chest until both mammary glands are covered in. (Fig. 537.) This bandage should be applied with uniform pressure. It is well adapted to support and to compress the breasts, either in cases of mammary abscess or to favor the absorption of morbid growth in the glands.

FIG. 538.

Velpeau's bandage.

Velpeau's bandage requires a roller two and a half inches wide and eight or nine yards long.

The patient having placed the hand of the affected side on the opposite shoulder, apply the initial end of the bandage at the posterior part of the axilla of the sound side, carry the roller obliquely across the back, over the side of the neck and clavicle of the injured side, thence down over the front and outside of the corresponding arm, under the elbow, and up through the axilla of the sound side. Make a second turn, following precisely the same course, until the point of the elbow is reached, when the roller should be carried around the chest, binding the arm to the body. After this the turns from the shoulder to the front of the elbow, and thence through the sound axilla, should alternate with the circular ones around the body until the arm and chest have been covered in. (Fig. 538.) This is one of our most useful bandages, serving frequently as a sufficient dressing in fractures of the clavicle, and of the acromial and coracoid processes of the scapula, and to give security to the arm after reduction of a scapulo-humeral luxation.

Provisional or Handkerchief Dressings.

To improvise a surgical dressing from common or ordinary materials is often a matter of great importance, and every surgeon doubtless has had frequent occasion to resort to many simple appliances in cases of emergency. Out of handkerchiefs and strips of muslin, M. Mayor, a surgeon in Switzerland, has devised a system by which, it is claimed, accidents may be treated quite satisfactorily, in the absence of the ordinary means, with materials within the reach of every one and to be found in almost every locality. I shall select from this system the dressings that, in my judgment, are most useful.

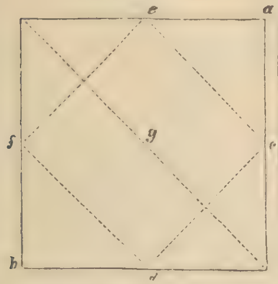
The basis upon which this system of bandages rests is the handkerchief or the muslin square; and could we always command the old-fashioned pongee silk or even the large cotton handkerchief of former days, there would be much to commend these dressings to general use. Unfortunately, however, it is only in those good old homesteads where the modern linen square of eight or ten inches has not yet displaced the ample bandanna, and where utility is exalted above display, that it is possible to procure a piece of the requisite size. It will be necessary first to describe the *forms* and *names* given to the different parts of these dressings.

The square.—The square is made either from a silk or a cotton handkerchief, or from a piece of muslin, flannel, or calico. This square may be changed into different forms by folding its parts together. (Fig. 539.) Thus, if the angles be turned in towards the centre, it will make a smaller square; if it be doubled upon itself, it will form an oblong. (Fig. 540.) If the two opposite angles of the square be placed together, it will make the *triangle* (Fig. 541), the parts of which are the *base*, *summit*, and *angles*.

When the triangle is folded from its summit towards the base, it forms the

cravat (Fig. 542), and if the cravat be twisted, it makes the *cord*, the parts of each being the body and the extremities. Handkerchief dressings are

FIG. 539.

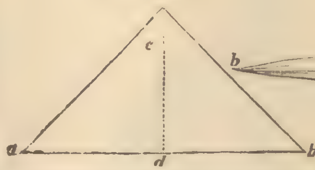


Square handkerchief.

FIG. 540.

Oblong handkerchief.

FIG. 541.



d, the base; *c*, summit; *a*, *b*, angles.

FIG. 542.

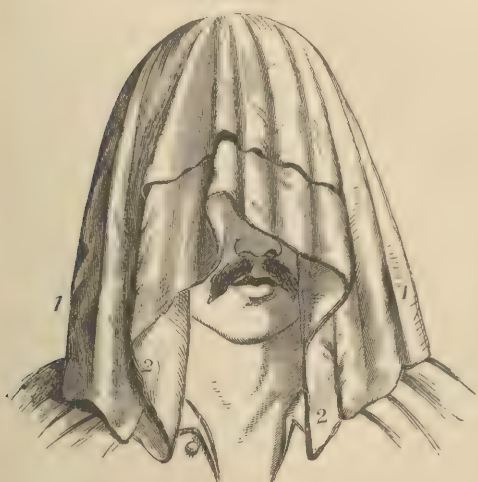
Cravat: *a*, body; *b*, *c*, extremities.

secured either by pins or knots. When a knot is adopted, it should be either a single bow or a cravat tie.

HANDKERCHIEFS FOR THE HEAD AND SHOULDERS.—There are a number of handkerchief dressings for the head and shoulders that are named according to the form which they take or the parts to which they are applied.

The square cap of the head.—Fold the handkerchief into an oblong square, the edge of one side being three inches in advance of the other. Place the long side next to the head, allowing it to hang down some distance in front of the face. (Fig. 543.) Seizing the ends of the uppermost or short side, draw them down and tie them under the chin; then draw downwards and

FIG. 543.



The first step in forming the square cap of the head.

FIG. 544.

Square cap of the head complete.

forwards the ends of the under or long side, and, folding them back, tie them behind, over the back of the neck. (Fig. 544.) This handkerchief covers in the entire head, and may answer the purpose of the recurrent roller; though it is too warm a dressing for comfort.

The fronto-occipital triangle.—In treating of these triangles, it will simplify the subject to remember that the base of the triangle is always placed over the frontal region and the apex or summit over the occipital. In forming, therefore, the one under consideration, the base of the handkerchief, folded in

a triangle, is placed over the forehead, while the summit is allowed to hang down over the occiput. The ends are next carried backwards along the sides of the head, above the ears, and either tied behind the occipital protuberance or crossed, brought forward, and pinned at each side, after which the apex is turned forward and pinned to the body of the handkerchief. (Fig. 545.)

FIG. 545.

Two views of the fronto-occipital handkerchief, anterior and posterior.

The occipito-frontal triangle differs only in reversing the handkerchief, the base being placed over the occiput and the apex over the forehead, while the ends are brought round, and either tied in front or crossed and pinned.

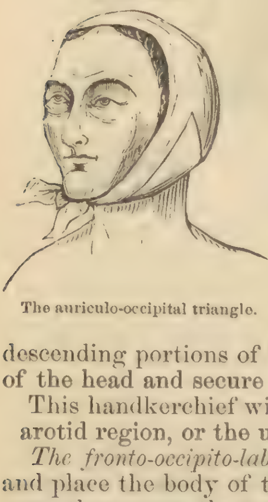
These handkerchiefs all fulfill very much the same purpose, viz., that of retaining dressings to the head.

The bi-temporal triangle.—The base is placed over one of the temporal regions and the apex over the other; the ends are carried round to the opposite temple, crossed, brought back, and secured with pins, and the summit or apex is turned up and pinned above the temporal ridge.

This triangle is designed to retain dressings upon the side of the head.

The auriculo-occipital triangle.—The base is placed in front of the ear to be covered, and the apex directed backwards. The lower end is next carried under the jaw and up over the face in front of the ear on the sound side, where it is made to meet the upper end, the two being tied together; or the two ends may pass, overlapping each other, and be pinned, the one beneath the ear of the affected side, the other in front of the ear of the sound side. (Fig. 546.)

FIG. 546.



The auriculo-occipital triangle.

This triangle will answer to keep a dressing in contact with the ear, such as a poultice or a lotion.

Vertico-mental triangle.—Place the body of the handkerchief over the vertex; bring the ends down over the ears, and cross them under the chin, carrying them upwards and pinning them to the descending portions of the handkerchief; last, bring the apex round one side of the head and secure it with a pin. (Fig. 547.)

This handkerchief will answer to retain dressings to the head, the ears, the arotid region, or the under part of the chin.

The fronto-occipito-labialis cravat.—Form the handkerchief into a cravat, and place the body of the same upon the forehead; carry the ends back, and cross them upon the posterior part of the neck, then bring them forward un-

derneath the ears, and cross them over the upper lip, securing the ends in the usual manner. (Fig. 548.)

FIG. 547.

The vertico-mental triangle.

FIG. 548.

The fronto-occipito-labialis cravat.

This dressing may be used to aid in supporting the approximation of a lip wound, in which case a compress should be placed on each side.

The occipito-sternal triangle.—Let one handkerchief be formed into a triangle and one into a cravat. Tie the latter around the chest, forming the sterno-dorsal cravat; place the body of the former over the occiput and its apex over the forehead, bring the ends down on each side of the face, and fasten them to the cravat about the chest. (Fig. 549.) The apex can be turned back over the vertex and pinned. This dressing may be used to approximate wounds on the front of the neck. The figure represents a night-cap drawn over the head and a part of the dressing, in order to prevent displacement.

FIG. 549.

The occipito-sternal handkerchief.

The parieto-axillaris cravat.—Form one handkerchief into a cravat, and place its body in the axilla, and tie the ends over the shoulder, forming the axillo-acromial cravat. Make a second handkerchief into a triangle, and, placing its body over the side of the head, tie its ends into the first, over the shoulder. (Fig. 550.) Care should be observed to protect the margins of the axilla against excoriation by interposing some cotton between the skin and the axillo-acromial cravat.

This handkerchief will serve to approximate wounds on the side of the neck, or to prevent contraction after burns.

The cervical cravat is made by forming a handkerchief into a cravat, and placing the body on the front, the back, or the sides of the neck, according

to the part to be dressed, the ends being carried round, crossed on the opposite side, and returned, after which they may be fastened with pins. The turns are made as one would apply the ordinary neck-handkerchief.

Fig. 550.

The parieto-axillaris cravat.

The axillo-cervical cravat.—Place the body of the cravat in the axilla, cross the ends over the shoulder, and tie them on the opposite sides of the neck.

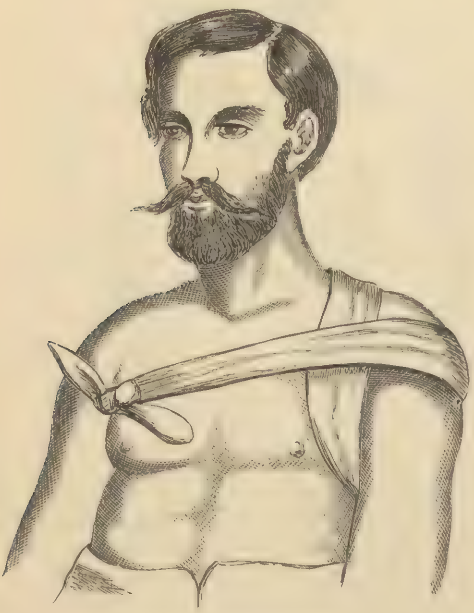
This cravat is well suited to retain a dressing in the axilla.

The simple bis-axillary cravat.—Place the body of the cravat in the axilla, cross the ends over the shoulder, and, after carrying one across the back and the other across the breast, tie them together at the anterior border of the axilla of the opposite side. (Fig. 551.)

Its use is similar to that of the preceding cravat.

The compound bis-axillary cravat requires two handkerchiefs in cravat form. One is tied as an axillo-acromial cravat through one axilla, while the body of the other is placed in the opposite axilla, and its ends being brought across the chest, one in front and the other behind, are passed through the loop of the first and tied in front of the breast. (Fig. 552.)

Fig. 551.



The simple bis-axillary cravat.

This handkerchief is designed to retain dressings in both axillæ.

The simple bis-axillo-scapulary cravat.—This is a posterior eight, and is best formed with a strip of muslin three inches wide and two yards long, as the handkerchief is ordinarily too short to make the necessary turns. Place the centre of the strip, or handkerchief, if sufficiently long, in front of the shoulder and the axilla; bring one end back over the top of the shoulder and the other through the axilla, cross them between the scapulæ, carrying the axillary end over the shoulder of the opposite side and back through the axilla, and the humeral end forward through the axilla, the two overlapping each other; then fasten their ends front and back. (Fig. 553.)

This dressing will answer as an extemporaneous one for fracture of the clavicle.

The compound bis-axillo-scapulary cravat.—Form two handkerchiefs into cravats. Tie one as a loose ring, or form the axillo-acromial handkerchief of one

Fig. 552.

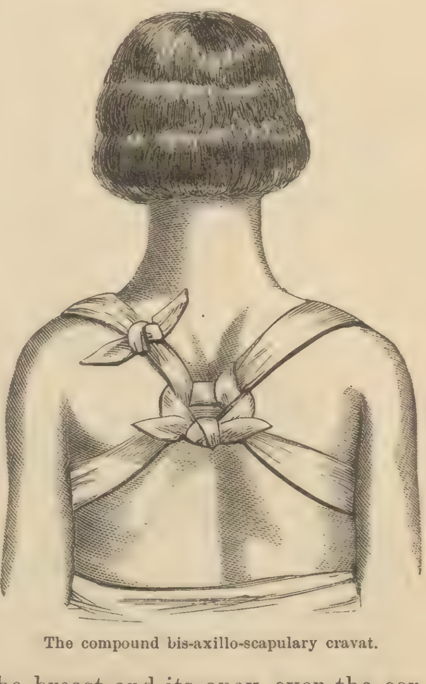
The compound bis-axillary cravat.

Fig. 553.

The simple bis-axillo-scapulary cravat.

side, and, placing the body of the other handkerchief in front of the opposite shoulder, bring the ends back, one over the shoulder and the other through the axilla; then form these into a single knot, and complete the dressing by passing the ends through the ring or loop of the other cravat, and tying them into a knot. (Fig. 554.) Whenever it becomes necessary to draw the shoulders back forcibly, this handkerchief may be used with advantage.

Fig. 554.



The compound bis-axillo-scapulary cravat.

The dorso-bis-axillary handkerchief.—Tie one handkerchief, formed into a cravat, around the body below the axillæ (bis-axillary cravat). Place the body of another, in triangle, upon the posterior part of the neck, securing the summit to the middle of the first on the back, and its ends or angles to the same in front. (Fig. 555.)

This handkerchief is well suited to retain a dressing in contact with the back, or the back and shoulders, and is really one of the most important of the entire class.

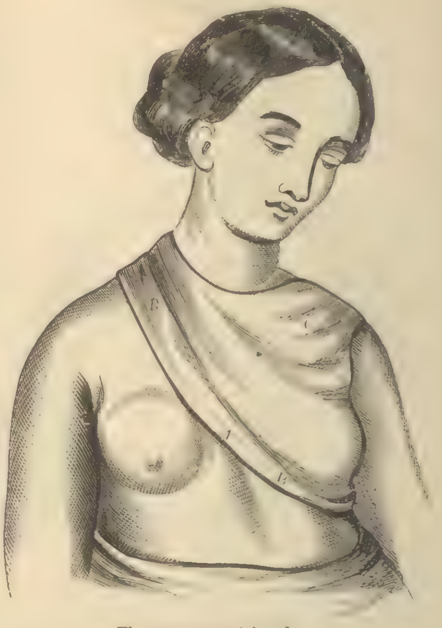
The mammary triangle, or the sling of the breast.—Fold a handkerchief into a triangle; place its base underneath the breast and its apex over the cor-

responding shoulder; then carry one end under the axilla, and the other over the opposite side of the neck, tying the two behind the scapula of the affected side, and pin to these the summit. (Fig. 556.)

Fig. 555.

The dorso-bis-axillary handkerchief.

Fig. 556.



The mammary triangle.

This triangle serves to suspend the breast, or to hold in place any dressing which may be applied to the gland.

Handkerchief Dressings of the Extremities.—Some of these are quite useful, others of very little practical value. The most important are the following:

The palmar triangle.—Place the base of a handkerchief in triangle across the back or the front of the wrist, according as it is designed to dress the palm or the dorsum of the hand; fold the summit back upon the wrist, and secure it there by carrying the ends around the same. (Fig. 557.)

Fig. 557.

The palmar triangle.

This handkerchief supplies the means of retaining poultices and other applications to the hand.

The triangular cap of the shoulder.—Place the base of a handkerchief in triangle over the insertion of the deltoid, and the apex over the top of the

shoulder, then carry the ends round the arm and tie them. I have found this handkerchief to maintain its position better by placing the base over the top of the shoulder, then tying the ends round the arm, and, turning the apex upwards, pinning it to the body of the handkerchief. (Fig. 558.)

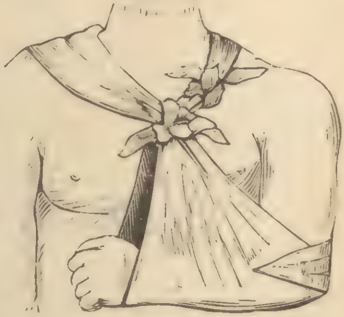
It is designed to secure dressings to the shoulder or the upper part of the arm.

The cervico-brachial sling.—Tie one handkerchief in cravat round the neck, so that it shall hang in a loose loop in front of the upper part of the chest. Place the base of a second in triangle under the wrist, and the summit behind the elbow, then fasten the ends to the cervical cravat, and bring the apex

FIG. 558.

The triangular cap of the shoulder.

FIG. 559.



The cervico-brachial sling.

FIG. 560.

Triangular cap for amputation, applied to the thigh.

forward around the elbow-joint, and pin to the body of the handkerchief. (Fig. 559.)

This dressing is commonly used to support the forearm, when flexed, after fractures, etc.

If the handkerchief is a large one, the cervical cravat may be dispensed with, and the ends of the triangle passed round the neck and tied on one side.

Triangular cap for amputation.—Fold a handkerchief into a triangle, and, placing the base under the stump, turn the summit up in front, and secure it by carrying the extremities around the limb and knotting them together. (Fig. 560.)

This cap answers the purpose, to some extent, of the recurrent roller, which is generally used to bind a dressing over the stump of an amputation.

The metatarso-malleolar cravat.—Form a handkerchief into a cravat, and place the body obliquely across the dorsum of the foot; carry one end under the foot and up in front of the ankle, and the other around the leg above the malleoli, attaching them together in front of the joint. (Fig. 561.)

Its use is to retain a dressing upon the foot.

The malleolo-phalangeal triangle.—Form the handkerchief into a triangle; place the base under the foot opposite to the instep; fold the summit back over the toes and the dorsum of the foot, and carry the ends round the malleoli, making them fast in front. (Fig. 562.) This handkerchief may be completed by tying the ends in front, or by crossing them over the dorsum and making them fast under the sole of the foot. It is sometimes called the cap of the foot, and answers the same purpose for the foot as the carpo-dorsal or palmar triangle does for the hand.

FIG. 561.

The metatarso-malleolar cravat.

FIG. 562.

The malleolo-phalangeal triangle.

The tarso-patellar cravat requires three handkerchiefs, all in cravat form. One is to be placed about the knee as a figure-of-eight; a second round the foot in front of the ankle; the third is passed through the loop of the latter, the ends being carried one on each side through the figure-of-eight of the knee, and pinned or tied as they are turned downwards. (Fig. 563.)

This dressing will serve a temporary purpose in holding the fragments of a broken patella approximately in position.

The tibio-cervical handkerchief, or sling of the knee.—Place the body of one handkerchief in cravat upon the shoulder opposite to the leg to be suspended, carrying the ends, one in front and one behind the body, across to the opposite side, and knotting them together. The other handkerchief form into a triangle, and, flexing the leg, place the base under the tibia, above the ankle;

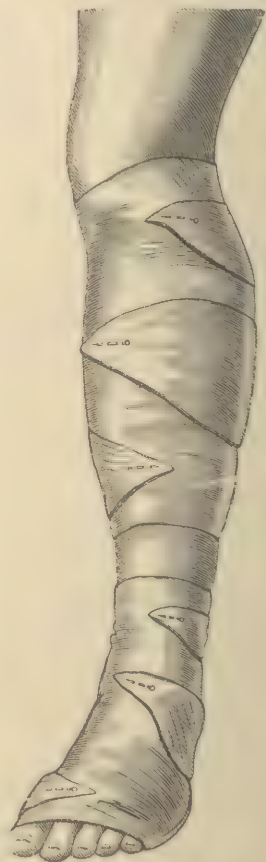
Fig. 563.

The tarso-patellar cravat.

Fig. 564.

The tibio-cervical handkerchief, or sling of the knee.

Fig. 565.



The tibial cravat. The cut also shows the cravat of the foot.

carry the ends up and tie into the cervical cravat; finish by bringing the summit round in front of the knee and pinning it to the body of the handkerchief. (Fig. 564.)

This sling will support the limb when the leg has been the seat of a fracture, and enable the patient to move about on crutches until it can be placed upon the floor.

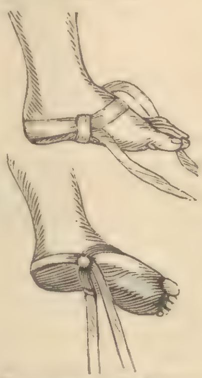
Tibial cravat.—Place the body of a handkerchief, folded into a cravat, obliquely across the posterior surface of the leg, and carry the extremities

around the limb, the one below the knee and the other above the malleoli. (Fig. 565.)

This handkerchief is well adapted for the purpose of retaining stimulating plasters to the limb.

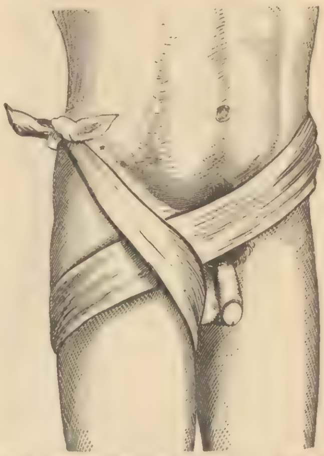
Barton's handkerchief.—This device of the ingenious surgeon, Dr. John Rhea Barton, is formed by placing the body of a narrow cravat around the point of the heel. One end, that corresponding to the outer side of the foot, should be a third longer than the other. The short or inner end should be held parallel with the foot, while the long or outer end must be crossed over the instep, turned round the inner end, carried back under the sole of the foot, and looped round its own side. The two ends may now be knotted together, drawn upon, and so adjusted that the pressure shall be exerted upon the instep and heel, parts naturally able to endure it. (Fig. 566.)

Fig. 566.



Two views of the Barton handkerchief.

Fig. 567.



The abdomino-inguinal cravat, or single spica of the groin.

This handkerchief is designed to make extension in fractures of the leg.

The abdomino-inguinal cravat, or single spica of the groin.—Two handkerchiefs, sufficiently long to make the dressing, should be folded into cravats, and their ends tied together. Place the body of one underneath the thigh, close up to the nates; bring the ends to the front and cross them over the groin, and finish by carrying them round the opposite sides of the body, and tying them together on one side rather than behind, so that the knot shall not press injuriously upon the back. (Fig. 567.)

This cravat may be employed to retain a dressing, or to make pressure over a bubo.

A second spica of the groin, which might be termed the *coxo-inguinal* handkerchief, is formed by spreading the body of a cravat widely, placing it obliquely across the hip and groin, and then carrying one end round the inner, posterior, and outer portions of the thigh, and the other end round the ilium and the sacrum, bringing it to the front of the groin, and connecting it with the first, or, if too short, pinning each separately to the body of the cravat. (Fig. 568.)

This handkerchief will answer very well to retain dressings which are required to be applied over the outer side of the hip, thigh, and groin.

The sub-femoral, or gluteal handkerchief.—Two handkerchiefs are required. One, in cravat, is to be tied around the body just above the crest of the ilium; the other, in triangle, is to be placed with its base obliquely beneath the gluteal fold, and the ends tied around the thigh. The summit is then passed under the body of the cravat, turned back, and pinned upon itself. (Fig. 569.)

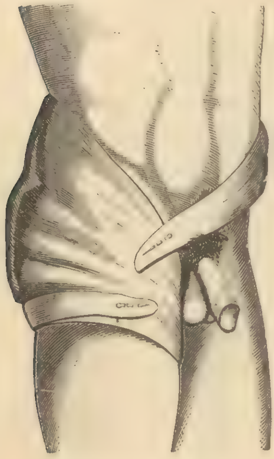
This handkerchief will keep its position with great certainty, and may be used to retain poultices or other applications to the buttocks.

Double spica.—Tie together two handkerchiefs folded each into a cravat; place the knot on one side of the lumbar spine, and, after bringing their ends forward along the sides of the pelvis, just below the crest of the ilium, carry them over the front of the groins, then down between the thighs, bringing them up in front, and, after crossing them over each other, fasten the ends to the body of the cravat with pins. (Fig. 570.)

This handkerchief will serve to retain a dressing to both groins.

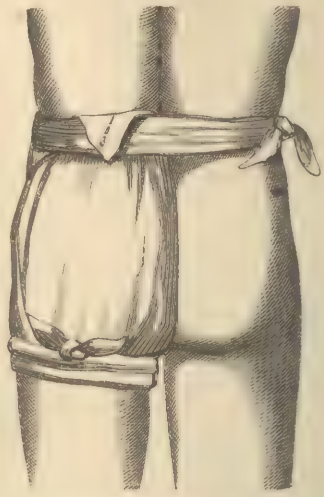
The suspensory, or scroto-lumbar triangle.—This dressing requires two handkerchiefs. One must be folded into a cravat and tied around the loins (lumbo-

FIG. 568.



The coxo-inguinal cravat.

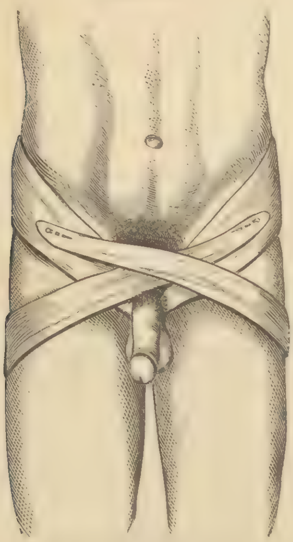
FIG. 569.



The sub-femoral handkerchief.

abdominal cravat); the other is to be formed into a triangle, the base of which should be placed under the scrotum, and the extremities brought up, passed beneath the circular cravat, and tied in front. The apex of the triangle

FIG. 570.



Double spica of the groin.

FIG. 571.

Suspensory, or scroto-lumbar triangle.

should be next carried up, passed beneath the abdominal cravat, and turned down in front, where it may be fastened with a pin. (Fig. 571.)

This bandage, in the absence of the ordinary suspensory, will fulfill most of the requirements of such a dressing.

CHAPTER X.

INJURIES AND DISEASES OF THE OSSEOUS SYSTEM.

FRACTURES.

What is a fracture? It is defined to be a solution of continuity in the fibres of a bone. It is an accident of great frequency, and more than any other has been a fruitful source of litigation between patient and medical attendant. In the management of such an injury the surgeon has much to contend with,—much that is calculated to create anxiety throughout the progress of the case. The frequency with which instances of deformity after fracture come under my observation would seem to indicate either incompetency or negligence on the part of those having the care of such cases, or insubordination of the patient while under treatment. If the former be the case, there can be no impropriety or injustice in holding the practitioner to a strict accountability. So many complications attend or follow these injuries, such as inflammation, abscesses, ulcers, hemorrhage, tetanus, delirium tremens, necrosis, gangrene, etc., that it is folly to regard this part of professional work as a mere mechanical one; on the contrary, it demands on the part of the surgeon not only the highest degree of anatomical skill and tact, but also a thorough knowledge of the principles of general medicine. From the patient there should be exacted the most implicit submission and docility. Whenever these cannot be secured, it will be altogether proper for the surgeon to relinquish the case, and to wash his hands of all responsibility. Professional bone-setters, as they are termed, have no claim to public confidence. They are generally both ignorant and rash. It should be remembered that a bone once broken, however simple the fracture, can rarely be repaired, even under the most skillful treatment, without some appreciable deformity or disability. There will be some inequality of the surface, or some shortening of the limb, or perhaps an abridgment of movement in a contiguous joint. There may be comminution of the bones, extensive damage to the soft parts, or many other complications, in consequence of which considerable deformity necessarily ensues, and for which no practitioner is to be blamed. In all cases, therefore, where the result of treatment is involved in doubt, it is the duty of the surgeon to state frankly to both the patient and the friends his apprehension, and thus prepare their minds for any unfavorable result.

Causes of Fracture.—These are twofold,—*predisposing*, and *exciting* or *determining*.

Predisposing Causes.—1st. *Function.*—Those bones which are concerned in prehensile and locomotive acts are, in consequence of their length, the powerful muscles by which they are controlled, and their exposed situation, very liable to fracture.

2d. *Form.*—The long bones, placed as they are in exposed situations, and influenced by the action of muscles, are oftener broken than the short or irregular ones: hence the infrequency of the accident in the vertebræ, as compared with the humerus or the ribs.

3d. *Mobility.*—Such portions of the skeleton as are not fixed by their articulations are less frequently broken than are others whose connections make them more stable: thus, the scapula and the patella commonly escape, while the nasal bones, the tibia, and the clavicle frequently suffer.

4th. *Age.*—No period of life, from the intra-uterine to extreme old age, is exempt from the accident of fracture. I have seen two cases of fracture of both bones of the leg in new-born children, which doubtless occurred before birth, and I have recently attended a case of fracture of the thigh in a lady ninety-two years old. In childhood, however, fractures are not common, for several reasons. The bones are more elastic; the epiphyses have not become solidly united to the diaphyses, and therefore the bones are more mobile; the ligaments are more pliable and supple; the muscles are incapable of exercising great power; and during the early years of life, children are usually protected from accident by those interested in their welfare. In mature life, fractures are among the most common occurrences, because it is the period when men are most engaged in active duties, and in the prosecution of those employments and occupations in which the body is most exposed to injury. In old age, though fractures are not so common as in ripe manhood, the predisposition to such injuries is greater from fragility or brittleness of the bones, consequent on their rarefied structure. There is also, in advanced life, a loss of balance between the animal and the earthy parts of the skeleton, which, with the diminished pliancy of the ligaments and the loss of muscular activity, strongly favors the occurrence of fracture.

Diatheses constitute predisposing causes of fracture, such as syphilis, cancer, rachitis, gout, osteomalacia, scrofula, etc.

A remarkable instance of senile fragility came under my notice in the case of an aged woman brought into the Pennsylvania Hospital during one of my periods of service, and who had twenty-four fractures of the ribs, produced by a fall down a flight of stairs ten feet high. The patient died shortly after her admission. Esquirol describes a woman's skeleton in his possession in which there were over two hundred fractures, and Malgaigne, on the authority of Saviart, a still more remarkable case of a woman, thirty years of age, who was believed to have had a fracture of every bone of the body. Nothing but a post-mortem, of course, could establish such a statement. Cases of multiple fracture are given by Gibson, Arnott, Lonsdale, and others.

In 1870 I treated a case of fracture of the thigh in a child aged three years, the same bone having been broken the year previous. This child belonged to a family of six children, every one of whom had suffered from a fracture of some part of the skeleton. Two of their number had sustained each three injuries of this nature, and an infant at the mother's breast, only three weeks old, had a broken rib, produced by being turned in its nurse's arms. The explanation of this I found was due to the presence of a syphilitic taint derived from the male parent. Dr. Bennet* presented to the Pathological Society of Dublin a number of fractures taken from a man who had been crushed by a falling roof. The femur, the tibia, and the fibula of the right leg were broken, the humerus and all the ribs of the right side, the first three ribs of the left side, and the sternum.

I can recall cases in which simply turning in bed was sufficient to cause a fracture of the thigh-bone. Most of these patients were women, some of whom suffered from cancer in the mammary gland, or from encephaloid disease of the omentum, and also of the femur at the seat of fracture. I have seen a case of fracture of the femur produced in the act of drawing on a boot, and of so serious a character as to be followed by death. There was reason to believe that a syphilitic vice was present and had affected the bones of this patient.

Gouty and rheumatic states of the system also predispose the bones to fracture, not only in consequence of structural alteration in the osseous tissue of persons so affected, but also from the muscular disability and the articular rigidity which so commonly attend these diseases, and which render the individual stiff and defenseless in his movements.

Exciting Causes.—These are *violence* and *muscular action.*

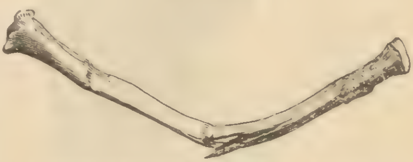
The violence may be applied to the bone either *directly*, as when a piece of timber or metal falls upon the leg, or when the latter is run over by the

* Dublin Journal of the Medical Sciences, September, 1874.

wheel of a loaded wagon, or *indirectly*, as when the force is applied remotely and is transmitted along the limb, expending itself destructively upon a distant bone. In this way an individual who falls upon his hand may break the clavicle, or a blow upon the top of the head may produce a fracture at the base of the skull. There are those who think muscular action does not often break a bone. I have frequently seen the patella broken by the powerful action of the quadriceps extensor femoris muscle, and in two cases have witnessed a similar injury to the thigh, where there was no ground for supposing that any diseased state of the bones had previously existed. I doubt not that the frequency with which drunken persons fall and escape fractures, where individuals in the full possession of their consciousness would probably not escape, is due in a great measure to the absence of muscular effort.

Division of fractures.—All fractures may be divided into *complete* and *incomplete*. *Complete* fractures are those in which the bone is broken entirely through. *Incomplete* fractures are those in which all the fibres of the bone are not severed. Under the last division come what are called "bent" or "green-stick" fractures. (Fig. 572.) The latter occur most commonly in the clavicles of children, and are occasionally met with in the bones of the forearm. A second division is into *simple* and *complicated* fractures.

FIG. 572.



Incomplete fracture of the radius.—Ferguson.

Simple Fracture.—Writers differ somewhat in their definitions of a simple fracture, but, without discussing this subject, I shall define such a fracture to be the *separation of a bone into two parts*. There is always more or less injury done to the soft parts, sometimes by the vulnerating body, and in every case to the parts immediately in contact with or contiguous to the seat of the fracture, by the ends of the broken bones. In several dissections which I have made in man, and in the lower animals, the periosteum was found broken, sometimes almost flush with the severed fibres of the bone, and at other times it was torn into shreds and separated from the osseous fragments for some distance from their extremities. The fibres of the muscles lying on the periosteum were also torn, and blood had extravasated through the interstices of the adjoining muscles as well as between their fasciculi.

Complicated Fractures are those in which there is added something more than the mere division of the bone into two fragments. These complications are the following:

Compound Fracture.—This is one in which there is a wound, forming a communication between the surface and the broken ends of the bone. This opening may be quite small, or it may be of considerable magnitude. The extremities of the bone may even protrude through the opening. A compound fracture may be either *primary* or *consecutive*,—that is, it may be compound at the time of the accident, or it may become so afterwards, from various causes. For instance, the fragments may be so near the surface that the attenuated skin will inflame, ulcerate, and open, or from the damage inflicted upon the soft parts an abscess may form which subsequently opens spontaneously or by the necessary interference of the surgeon.

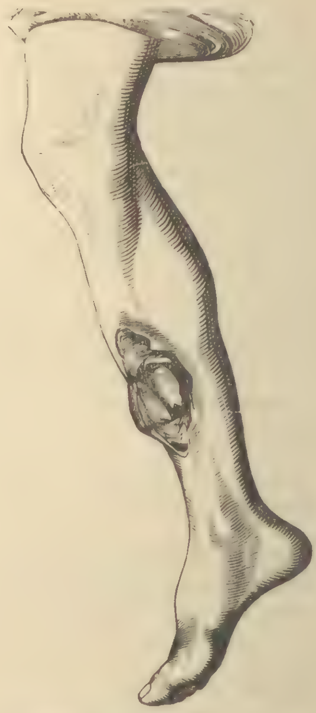
Comminuted Fracture.—In this complication the bone is broken into three or more pieces. This definition requires some limitation. A bone may be broken at its upper and lower extremities,—a *multiple fracture*,—and, although there would be in such a case four fragments, yet it would not be, in the technical sense, a comminuted fracture. It is only such when the lines of fracture communicate with one another. (Fig. 573.) Under this head may

also be placed the *stellated fracture.* Should such a fracture be associated with an external wound, it is then a *compound comminuted fracture.* (Fig. 574.)

FIG. 573.

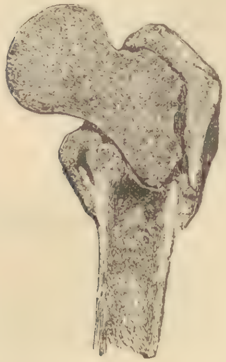
Comminuted fracture.

FIG. 574.



Compound comminuted fracture of the leg.—After Miller.

FIG. 575.



Impacted fracture of the neck of the femur.—After Miller.

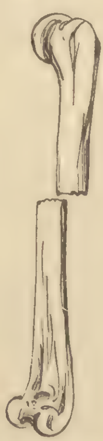
Laceration of a principal artery or nerve.—This accident is sometimes produced by a displacement of one of the fragments of a broken bone, or by the missile which determines the fracture, and is always a serious complication.

Dislocation.—The force which causes a fracture may at the same time produce the luxation of a contiguous joint, and thus convert a very simple accident into a very embarrassing one.

FIG. 576.

Oblique fracture.

FIG. 577.



Transverse fracture.

Impaction consists in the end of one fragment of a broken bone being driven into the cancellated tissue of the other, so that the two become locked together. (Fig. 575.)

Delirium tremens and low forms of fever.—The favorable progress of a case of fracture may be seriously interrupted by the occurrence of an attack of mania a potu, or by the invasion of typhoid or some other form of fever.

Direction of fracture.—The direction in which the bony fibres yield may be *oblique, longitudinal,* or *transverse.*

The Oblique Fracture is the prevailing form. Such a direction becomes almost a necessity when we consider the structure and arrangement of the fibres of a bone. Some fibres are more elastic than others and will bend, while their neighbors will break. The same fibre is not equally strong at all points. These fibres again constitute a system of intersecting arches, some of which will be more affected by force than others, so that the momentum attending a blow will not travel in a direct line, but in one more or less irregular. (Fig. 576.)

Transverse Fracture is one in which the separation is in a direction at right angles with the long axis of the bone. (Fig. 577.) In the short bones, such as those of the carpus or the tarsus, or in flat bones, like the scapula or the ilium, such fractures frequently take place, but in the long bones their occurrence must be exceedingly rare. I have seldom seen one in the adult which could be strictly so regarded.

What are called *epiphyseal fractures* are transverse of necessity. (Fig. 578.) These may occur at any period before that in which the epiphysis and the diaphysis are solidly united by bony matter; though they are not common, as the elastic character of the intermediate uniting cartilage tends to prevent rather than to favor such an accident.

Longitudinal Fractures are those in which the fracture runs in a direction parallel with the long axis of the bone. (Fig. 579.) This fracture is comparatively rare in civil surgery, though in military surgery it is frequently seen, and is the result of the formidable cylindro-conoidal ball.

FIG. 578.

Epiphyseal fracture.

FIG. 579.

Longitudinal fracture.

Signs of Fracture.—The signs of fracture should be carefully considered. Taken in their clinical order, that in which they generally present themselves to the surgeon, they are, first,

Deformity.—The part injured has lost its usual appearance; it does not answer to the corresponding part of the sound side. Such comparisons should be made by ocular inspection, the limbs being placed side by side. It is in such injuries that surface anatomy becomes so valuable,—that is, a perfect familiarity with the normal contour of the parts. The deformity present will depend on the degree of displacement and the consequent swelling. There are various causes for this displacement, among which may be enumerated, 1st, the *force* which produces the fracture, driving the fragments into unnatural positions; and, 2d, *muscular action*, which is perhaps the most influential of all. Whenever the resistance which keeps the origin and insertion of a muscle at a given distance from each other is removed, the tendency of the muscle is to shorten. Allow a limb to remain any considerable time flexed, and the flexor muscles will become so shortened that it can with difficulty be straightened. In a broken limb, the bony resistance being lost, the same contraction takes place; and this action is often intensified by the irritation to which the contiguous muscles are subjected, from contact with the angularities and the asperities of the fragments.

The weight of the limb constitutes another factor in the displacement, and especially when the part has been imperfectly supported. One of the best illustrations of this statement is seen in fracture of the clavicle, in which case the weight of the entire shoulder acts on the outer fragment, carrying it out of its proper position.

The *displacement* may be either *longitudinal*, *angular*, *transverse*, or *rotatory*.

Longitudinal displacement is that which takes place in the direction of the length or long axis of the bone. The oblique line of the fracture favors, by its mechanical form, this displacement, one fragment sliding past or over the other, producing what is termed overlapping or *shortening*, and occasioning that deformity which is the most constant source of anxiety to the medical attendant. As this is due to muscular action, it may, instead of making the

fragments overlap, exercise an opposite effect, and draw them apart, as in fractures of the patella or of the olecranon process of the ulna, and those through the neck of the condyle of the inferior maxillary bone.

This shortening of a limb after fracture may be much greater several hours after the injury than at the time of its infliction, particularly when the violence has been directly applied, in which case the muscles are so paralyzed that they are incapable of drawing the fragments, to any extent, past each other. After a time, however, when they have recovered their power, the shortening will become very evident: hence the necessity of taking advantage of this period of enfeebled muscular action to adjust and confine the fracture accurately.

An examination of the various collections of fracture specimens will convince any one that under the most skillful management some degree of shortening will generally take place, nay, may be confidently expected.

Angular displacement.—In this displacement the fractured ends are at an angle, more or less obtuse, with each other. (Fig. 580.) This forms a very serious deformity, and in most respects is more to be deprecated than the longitudinal displacement, as it is often increased, when in the lower extremity, by the weight of the body, even after the union has become consolidated, and by changing the line of muscular action greatly disables the patient in his movements. The chief element in its production is muscular action. There are cases in which it cannot be avoided, as in certain comminuted fractures, or where one fragment impales the other.

Fig. 580.

Angular displacement.

Fig. 581.

Rotatory displacement.

Transverse displacement.—Such a displacement consists in the end of one fragment resting in part against the end of the other. Its occurrence is certainly not common.

Rotatory displacement.—This displacement consists in one of the fragments being turned upon its axis. (Fig. 581.) The weight of the limb and the action of the muscles are the co-efficients which determine it. Either fragment may undergo this rotation, although it is generally the lower one. In fracture of the femur it may occur from allowing the foot to turn too far outwards, and in fractures of the bones of the leg below the knee it is produced by the same cause.

Preternatural mobility.—This forms another important evidence of fracture. The existence of mobility in the shaft of a bone cannot occur without a break in the continuity of its structure. When the injury is very near to a joint, there will be more difficulty experienced in distinguishing between the motion due to fracture and that due to the movements of the articulation, and we may have on this account to rely on other symptoms for the resolution of our doubts. There are other conditions, however, in which the sign of mobility loses its value, as in a fracture at the surgical neck of the humerus, attended with inflammatory stuffing of the surrounding parts; or when the lesion is in the neck of the femur and accompanied by impaction; or in the leg or the forearm, when only one bone is broken and the fragments are not displaced.

Crepitation.—Of all the signs of fracture this is the most conclusive. It is that sound or sensation which is produced by rubbing together the ends of the broken bone. It has been well said to resemble the sensation which is elicited by rubbing together two pieces of loaf-sugar,—it can be both heard and felt. There are conditions in which it may not be present, as in impaction,

or in cases of incomplete separation of the fragments, or where there is great overlapping of the ends of the broken bone. There is a sound sometimes recognized which may be confounded with that of fracture crepitus. It is the result of diseased cartilages, of preternatural mobility in a joint, or of a fibrinous exudation into the sheaths of tendons, or it may arise from an inflamed bursa. An experienced hand and ear will not likely be misled. This imitation is properly a moist friction-sound, much softer and less grating than that of true bone crepitus. There is, however, a condition in which the two sounds are almost identical, as where the examination has not been made for several days after the accident, in which case the inflammatory softening at the ends of the bone, together with the plastic products around, furnishes a soft, dull crepitus to the hands of the surgeon when the fragments are pressed against each other. In handling a part with a view to ascertain the existence of crepitation, the medical attendant should proceed with clear and definite ideas. There should be no unnecessary or aimless movements made, inflicting thereby uncalled-for pain. At the same time, he must not, from timidity or misplaced sympathy, stop short of a thorough examination. If the damaged part be an arm or a leg, the limb should be firmly grasped by the hands, one above and the other below the supposed seat of fracture, and movement made in opposite directions; or one hand may remain fixed and the other be moved; or it may be necessary for the physician to grasp the limb at the seat of injury with the hands,—as in the case of a broken thigh,—while an assistant extends the leg by drawing on the foot, and afterwards rotates the limb. By these manipulations the ends of the fragments can often be brought into such a relation with each other as to produce the characteristic sound. In obscure or doubtful cases the use of the stethoscope has been suggested by Lisfranc and others; but where such refinements are called for, great caution should be exercised, as sounds which can be recognized only by this instrument might readily be confounded with those which follow the movements of a tendon or the friction over a bursa.

Loss of function.—Generally speaking, there is inability to execute the ordinary movements of the part. A man cannot walk on a broken leg, raise weights with a broken arm, or breathe fully with a fractured rib. This is due to two causes,—the pain which results from such attempts, and the uncertainty with which the muscles act on a broken lever. Exceptions to this general statement, however, frequently occur. The murderer of President Lincoln was able both to walk and to run on a broken fibula. I have frequently seen the arm moved with great freedom in fractures of the clavicle, particularly in children, and I have known a sailor walk two squares, and to the third story of the Pennsylvania Hospital, with a broken thigh. In the same institution I have seen a patient walking with a broken patella. Where impaction or an incomplete fracture exists, such ability is easily accounted for, as the continuity of the lever is not lost.

Pain.—It has been very properly observed that many diseases can be recognized by the character of their pain, just as we can distinguish persons by the tone of their voices. In fractures the pain is unlike that resulting from other injuries. It is of so acute and intense a character that the movement of the fragments will elicit a sudden, sharp, involuntary cry from the most stolid. The late Dr. Barton noticed this fact long ago, and attached to it much importance. The pain, it may be stated, is, as a rule, dependent on the movement of the parts. Tenderness or increased sensibility will be present for some time after a fracture, and, indeed, may be persistent throughout the entire course of treatment.

Discoloration.—There are two sources of discoloration. *First*, it may arise from the blood-vessels of the subcutaneous connective tissue being ruptured by the direct application of force, in which event it will be apparent almost immediately after the accident, or in a very few hours following. The inflammatory exudation which succeeds such an injury will

sometimes result in large blebs or vesications, giving a dark or mottled appearance to the part. The *second* source of discoloration is from the vessels of the bone and the contiguous parts. This makes its appearance after the lapse of two or three days, or later, simply because the blood finds its way with difficulty towards the surface through the little apertures in the deep fascia traversed by the vessels and nerves. In cases of intracapsular fracture at the hip I have known eight days to pass before discoloration or ecchymosis became visible. In one instance so great was the discoloration that I was called by the medical attendant to amputate the limb, under the impression that the leg was in a state of mortification.

Disordered sensibility.—This may manifest itself by a burning, tingling state of the parts below the injury, by paroxysmal attacks of pain, or by numbness, and must be referred to injury of the adjacent nerve-trunks by the fragments of bone. It frequently provokes muscular spasm, which not only involves acute suffering, but also proves instrumental in disarranging the adjustment of the fracture.

In persons of a highly-organized nervous system, after recovering from the shock of a fracture, intermittent muscular spasms occasionally occur, even when there is no evidence of nerve-pressure. In a patient whom I once attended for a broken thigh, so highly was the reflex sensibility of the muscles developed that simply touching any one belonging to the injured limb would cause it to start out in a strong, cord-like swell.

Time to examine.—For several reasons, the sooner after the injury the examination of a fracture is made, the better. The sensibility of the parts from the local shock is less acute at this time. Nor is there any great swelling to mask the true nature of the injury. At this time the salient points of the skeleton, the relations of which are so important to a successful examination, are easily touched. To defer an immediate examination is to intensify the subsequent inflammation. In fact, every important sign of fracture is rendered less pronounced by delay. The fact that the work of repair in a fracture does not begin until some days after the reception of the injury is no argument whatever for procrastination.

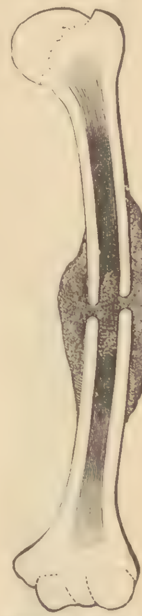
Repair of Fractured Bones.

In the whole range of surgical pathology there is no process so interesting, and none which so challenges our admiration, as the process by which nature repairs a fractured bone. Mr. Stanley remarks, very properly, that "bone holds a high place among the animal structures." The notable distinction consists in its possessing a developmental force equal to a complete reproduction in all the details of formal perfection, even when the osseous tissue is mutilated by force or destroyed in its entirety by disease.

What is the condition attending or immediately following a simple fracture in a bone? There is the severance of its continuity or rupture of its bony fibres; the laceration of the medullary and other vessels of the structure; the rupture of the periosteum, and, generally, injury to a greater or less degree of the parts immediately contiguous to the bone. According to my observation, in experiments on the lower animals, it is rare for a fracture to occur without the periosteum being broken or divided in the entire circumference of the bone. It may be severed on a line with the fracture, provided the direction is not too oblique, or it may occasionally yield at several points, leaving others which, though stripped off some distance from the surface of the bone, still serve to hold the ends of the fragments loosely together. The muscular fibres which lie in contact with the periosteum are often broken, torn perhaps by the irregularities of the fractured ends. Blood is poured out, and that blood, both arterial and venous, comes from the medullary vessels, the vessels of the Haversian canals, the periosteum, and the parts in close proximity to the injury. This blood finds its way into the medullary canal between and around the fragments, and into the intermuscular spaces

around the seat of fracture. (Fig. 582.) After the lapse of time it forces its way through the deep fascia by the apertures for the passage of the small vessels, and then spreads through the subcutaneous cellular tissue, producing the ecchymosis seen beneath the skin. The firmness of the coagulum is most marked at the seat of fracture. That which reaches the surface is usually a blood-stained serum, and less coagulable than that which lies deep. Mr. Paget, in speaking of the blood in fractures, says "the abundant extravasations that commonly exist in the subcutaneous tissue are generally confined to it, and are not continued down to the periosteum or to the bone." This is true as regards the blood derived from the subcutaneous vessels, but it is not to be inferred from this statement that there is no blood below the deep fascia. On the contrary, it will be found extending from the fracture to the surface, and in not a few instances, particularly where the bone has been broken by indirect force, all the hemorrhage, whether superficial or deep, has been derived from the seat of fracture.

Fig. 582.



Disposition of the blood after a fracture.—Miller.

What becomes of this blood?

This question is a difficult one to answer. A certain portion is doubtless removed by absorption,—that is, it is taken up by the veins and the lymphatics, and is eliminated with other effete products of structural change. Still, I am convinced that there is another disposition of it. When once out of the vessels, the force which bound together its various components is no longer operative, its unity is lost, and it reverts into its separate chemical units, some of which, being of a kind similar to the structures with which they are in contact, become incorporated with them through cell agency. The hemorrhage which follows the laceration or rupture of the blood-vessels of the bone gradually subsides, and in the same way as after a wound in the soft parts, namely, by the blood coagulating within their canals up to a collateral branch. The effect of depriving the bone of the blood that previously supplied these non-obstructed arteries is to induce a limited necrosis, in which the inorganic and the organic portions of the structure fall asunder and are removed by absorption, just as diseased parts of a vertebra are disposed of without any external opening. But we advance a step further. As a consequence of the damage sustained by the broken bone and the surrounding parts, inflammation is induced, giving rise to a copious transudation of a fibrogenous material, and to the presence of vast numbers of corpuscular bodies or leucocytes, which have passed through the walls of the contiguous vessels. This transudation becomes intermixed with portions of the extravasated blood both surrounding and interpenetrating it, so that it becomes in a measure less firm in its consistence, and acquires a reddish stain, the whole mass forming a gelatinous substance often of a pinkish color. The vessels which participate in this work are all the vessels belonging to the bone, the periosteum, and in some degree those of the soft parts immediately adjacent, though it would appear that those of the inner layer (osteogenetic, as it is called) of the periosteum are most actively engaged in furnishing reparative material. In support of this view we find this membrane apparently separated a considerable distance from the bone above and below the line of fracture, though really incorporated with the new deposition, which is most abundant opposite to the fracture, so as to give this part of the bone a fusiform or spindle-like appearance (Fig. 583), and forming what was formerly called the "ring," while that which occupies the medullary canal, in case there is no displacement, plays the part of a pin (Fig. 584), thus giving to the bone a considerable degree of support and firmness, which tends to prevent its displacement. Where over-

lapping exists, the new material is placed between the contiguous surfaces of the bone as well as around them, as seen in Fig. 585, taken from a fracture thirteen days after it was made.

In a short time this material, consisting of cartilage-cells and an intercellular substance, granular and striated, becomes of a much firmer consistence

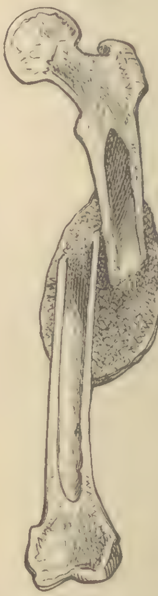
Fig. 583.

Spindle-shaped appearance of the reparative material after fracture of the humerus.

Fig. 584.

Showing the external and internal callus, or the ring and the pin.—Paget.

Fig. 585.



The position of the reparative material in a fracture with overlapping.

by the deposition of saline constituents, constituting what is termed *callus*, or elementary bone, and, coincident with this, the bond of union between and around the broken fragments becomes more firm. The amount of callus will be determined very much by the degree of motion to which the bone is subjected, and also by the accuracy of the adjustment. The more the ends of the bone are disturbed, and the greater the overlapping, the greater will be its quantity. As much of this reparative or reconstructive material disappears after the solidification of the fracture, it has been called *provisional callus*, while that which is more particularly concerned in cementing together or restoring the continuity of the bone-tissue is styled *definitive callus*. These terms, introduced by Dupuytren, are perhaps calculated to beget erroneous ideas as to this remarkable process. They would seem to imply that the first (provisional or ensheathing callus) is merely an improvised material, which, like the scaffolding of a building, is wholly taken away when the building is finished, or as soon as the definitive callus—an after-production—is laid down and inwrought with the texture of the broken ends. This is true of that within the medullary canal, but not entirely so of that surrounding the fracture. Mr. Paget denies the existence of the ensheathing callus, except in the case of the ribs, and perhaps the

clavicle. I can discover no ground for such a distinction. The ensheathing callus is always present to some extent; it becomes definitive callus; they are only stages of the same process. The former exists in all fractures of the long bones, and only that which is in excess of the necessities of the case is subsequently removed, just as the redundant lymph which may be about a wound in the soft parts is removed. But the work is not done. The union between the opposing ends of the fracture, when accurately adjusted, does not take place until much of the callus without and within the bone has been formed. This is probably explained by the fact that the compact tissue is less vascular, and consequently furnishes a less abundant supply of granulation material. The first urgency being met, that of bridging over the chasm and giving a degree of fixation to the fragments by establishing their firm continuity, the work of *modeling*, or the perfecting of the process, is commenced, just as the sculptor, after cutting out the outlines of his figure, applies himself to the finer details of his work. All excess of callus is removed by a retrograde metamorphosis; to this extent it is provisional. The very intimate union between the animal and earthy constituents of the callus begins to dissolve, the cohesive power of the twain is lost; the salts are first removed, and then follow the animal or organic matters; all irregularities or angularities are rounded away; the structure of the callus, at first all compact, and filling the medullary canal and the spongy tissue around, becomes more open and porous by its partition-walls disappearing, and by the consequent enlargement of the cancelli, until at last the medullary canal is restored, as well as the cancellated tissue of the bone. Not only does this occur when the apposition has been accurate, but also when the overlapping has been considerable and with no small amount of interposed callus. This re-absorption of the compact walls of the bone, opening the medullary canal of one fragment into that of the other, as seen in Fig. 586, may require years for its completion, long before which the elementary callus has become perfect bone, possessing, even at an early period, Haversian systems, lacunæ, and canaliculi. The particular in which callus differs from mature bone is in the proportion of its animal and earthy components, callus having over twenty per cent. more of the salts of lime than ordinary bone, thus acquiring the increased hardness so necessary to the office which it fulfills.

Fig. 586.

The cancellated tissue being gradually re-formed, and the compact walls of the overlapping fragments being gradually removed, in order to establish the continuity of the medullary canal.—Paget.

The development of the organizable material of the callus into true bone will be best illustrated by introducing at this point the results of a number of experiments which I made upon the bones of chickens. For this purpose, numerous fractures were produced, and dissections, followed by microscopic examinations, made at various periods from one hour and a half after the injury until the twenty-fifth day. These fractures were all simple. It has been stated that after such an injury the blood finds its way into the medullary canal between the fragments, adheres to the edges of the periosteum when torn, and permeates the muscular and the connective tissue next to the bone. This describes most accurately the appearance presented in the first dissection I made one hour and three-quarters after the injury.

A second dissection was made three days later. After removing the skin and fascia, the seat of damage was recognized by a swelling over the break, of a peculiar spindle-shaped form. Even the tendons were curiously spread out into a ribbon-like expansion, and quite adherent to the parts underneath. On the fifth day this enlargement is probably at its height, and at this time a specimen was divided longitudinally, for the purpose of study. The periosteum was separated for over half an inch above and below the seat of fracture. At the latter point the separation was greatest, becoming less above and below: hence the spindle form of the enlargement. To the unaided vision, the same material which lay beneath the membrane was also external to it, so that the periosteum was in reality imbedded in or incorporated with it. It was also seen between the ends of the bone when not displaced, or between the contiguous surfaces when overlapping, and finally for some distance up and down the medullary canal. This preliminary formation was a light-colored, consistent substance, interspersed with dark-red spots, and gave to the fracture a considerable degree of fixation.

This specimen was placed for microscopic examination in charge of Dr. Rhoads, who furnished me with an opportunity to study each section, in order that the appearances might be more vividly impressed upon my mind. The material in contact with the fracture was found to consist of blood-corpuscles in various stages of disintegration, some adhering in rolls and preserving in some degree their form, some isolated, others collapsed, with irregular or stellated margins; homogeneous lymph; and great numbers of the so-called germinal corpuscles, or, in the light of more recent discovery, leucocytes. These components were irregularly intermixed, and here and there stained with what seemed to be the coloring-matter of broken-down blood-corpuscles. The leucocytes varied much in form; some were round, others oval. They varied also in size, as though under the active process of change.

In the compact portion of bone, a noticeable contrast existed between the Haversian canals near the fractured ends and those more remote. The size of the former was much greater, and they presented at numerous points little recesses or loculi, leading off from their sides. The blood-vessels could be distinctly seen, but they were pushed off from the sides of their bony canals, the intermediate space being occupied by crowds of cells in all respects like those exterior to the bone, and which came, no doubt, from the Haversian vessels. Now, as the Haversian canals open into the medullary space, and also upon the broken surfaces of the bone, the conclusion was inevitable that many of the cell-bodies seen in the medullary canal came from these sources, as well as from the vessels of the medullary membrane. In this rapid enlargement of the hard bony canals traversed by the blood-vessels, we have an example of one of those singular changes which attend inflammation, and which it is difficult to explain. That it is due to absorption from the pressure exerted by the exudation is exceedingly improbable, as such pressure would destroy the contained vessels rather than affect the bony walls with which they are surrounded. In studying the inflammatory process in other tissues, a somewhat analogous phenomenon may be witnessed. In cartilage, for example, the normal corpuscles which lie imbedded in the intermediate substance have their places occupied by a multitude of leucocytes, more changeable and active than those which they have replaced, and whose insatiate demand for pabulum compels them to prey upon the matrix, the consumption of which gives the structure an open, reticulated, or honeycombed appearance. It is quite probable, therefore, that the organic constituents of bone may be attacked by the migrated cells of its vessels, and, thus separated from the bone-salts, give rise to the enlarged canals and their irregularities. The phenomena presented in this first specimen appear, then, to have been those of an inflammatory character, in which all parts of the bone at and contiguous to the fracture were engaged. The periosteum incorporated with the reconstructive material in seven or eight days entirely disappeared

as such, undergoing those changes which inflammation produces in ordinary connective tissue, while a new membrane was produced external to the spindle-shaped mass of new matter, and continuous with the old periosteum at the limits of the separation.

A second specimen, nine days old, was subjected to a similar examination. In this fracture the periosteum had not been entirely broken, and consequently there was no displacement of the fragments. It was divided longitudinally. The periosteum was not torn from the bone, but was separated by the exudation for about one inch above and below, in the same fusiform or spindle-like manner as in the specimen first studied, only to a greater degree. The reconstructive material lay between the bone and the periosteum, external to the latter, between the ends of the fracture in small amount, and within the medullary canal. This does not accord with Mr. Stanley's statement, who alleges that when thus apposed, and without disturbance, no provisional callus is supplied by nature, but that immediate union takes place, an opinion in which, I believe, Mr. Paget concurs. The stage of organization was not alike in all portions of the new material. The development was evidently advancing from without inwards. The greater part of this new formation consisted of round, oval, and elongated masses of germinal matter, surrounded by a faintly granular and fibrillated intercellular or formed material. These cells were in some situations grouped irregularly, at others arranged in an orderly manner in concentric ranks, corresponding to the canals seen a little later, and foreshadowing the laminæ of the Haversian systems. The cells which lay between the ends of the bone and in the medullary canal were more numerous and less distinctly altered from the globular form, and were greatly in excess of the intercellular or formed material; this latter was still mingled with a little broken-down blood. In the angles between the periosteum and the bone, and in an oval space near the centre of the external or ensheathing matter, the transformation into soft bone had taken place by the deposit of bone-salts. In these situations the Haversian canals were large and numerous, running, some diagonally, others perpendicularly, between the periosteum and the old bone. Simultaneous with the calcareous conversion of the intercellular material were the formation of the canaliculi and the shaping of the previously-arranged cells into distinct lacunæ.

In the spindle-shaped envelope or ferrule we have the ensheathing callus of Dupuytren, or what he termed *provisional callus*, while the portion occupying the canal answers to the pin. These, according to this distinguished surgeon, were only temporary in their duration,—splints, in other words, to maintain a degree of connection until a secondary deposit took place between the ends of the bone, after which the former were removed, being no longer of use.

Other specimens were examined on the thirteenth and seventeenth days. These exhibited a more advanced stage of ossification, though in some places many cells were seen which were not cartilage-cells. Between the broken ends the intercellular substance had increased, and some progress had been made in its conversion into bone, permitting much less movement at the break. At other portions of the callus, canaliculi were forming in the intercellular material, and which evidently commenced on that part of the callus most remote from the lacunæ. The entire mass of new bone was a trifle more open and spongy in its texture, and of a slight rosy tint. Anxious to determine the vascularity of the reconstructing substance, on the fifth day after making a fracture of the wing of a chicken a delicate pipe was inserted into the brachial artery, through which I injected some ultramarine suspended in glycerin. A section was made of the bone and submitted to Dr. Rhoads for examination. Although the injection was not so satisfactorily done as I could have wished, yet the coloring-matter had filled numerous vessels throughout the callus. These vessels in the external callus ran for the most part perpendicularly down, the callus ossifying around them.

Two additional specimens, one twenty-one and the other twenty-three days old, were carefully studied. The appearances presented were entirely in harmony with the previous specimens. The entire reconstructing material had been converted into bone, so that scarcely a trace of cartilage could be seen. The amount of exterior callus had diminished and become more compact, and that between the ends of the bone, though much less perfectly transformed into osseous tissue by the deposit of the bone-salts in the intercellular substance than other portions, had nevertheless made material progress.

Meescher and Votsch state that ossification in birds is always in cartilage; Wagner states virtually the same in the case of rabbits, and in all the cases which furnished the subjects of the present experiments the same fact was observed. It is asserted that in man the repair or ossification may take place either in cartilage, or in fibrous or fibro-cartilaginous tissue. This statement needs confirmation. At the time I was engaged in these experiments a patient was admitted into the Pennsylvania Hospital who had broken his femur in the lower third in the act of pulling off his boot. Six weeks after, the man died, and I had the opportunity of examining the bone. Though the fractured limb had been kept perfectly quiet, the appearance presented was identical with that of the bones which I had under experiment. There was the same spindle-shaped swelling on the exterior of the bone, extending for two inches above and below the fracture, and most of which had been converted into bone, while in that portion between the ends, and where the process was less advanced, lay cartilage-cells imbedded in a vitreous-like matrix, but not a trace of connective or fibrous tissue. Of course it would be unsafe to speak dogmatically from a single example, but it is sufficient to excite a doubt as to union, save through cartilage tissue. It is certainly true that the amount of peripheral callus is greatly influenced both by the relation of the fragments to each other and by the degree of disturbance to which they are subjected, becoming exuberant when there is overlapping, and especially so when the ends are not sufficiently immobilized; but I think that any one who will study the fracture specimens in our museums will be convinced that in all long bones, whatever may be the age of the specimen, there is manifest evidence of an ensheathing callus, increasing somewhat the volume of the bone at the seat of injury. The conclusions which I think are rendered probable by these and other observations are the following:

First. That there is no evidence founded on structure, that the process of healing in the fractures of man may not be studied by experiments on the lower animals, or that the repair in the latter materially differs from that in the former.

Second. That the reparative act is the result of an inflammatory process.

Third. That the reparative material is furnished by the vessels of the periosteum, endosteum, and bone, and to some extent by those of the adjacent soft parts.

Fourth. That the uniting material is deposited external to the bone, constituting an ensheathing callus; also in the medullary canal when there is no displacement, and between the ends of the bones; that the conversion of this preliminary substance into bone proceeds from the surface towards the centre, so that the exterior is hard long before the interior, which will account for the movement discoverable in specimens apparently solidly united together.

Fifth. That the union of bone is through cartilage, and even through cells which have not reached the typical form of cartilage, and in this respect does not materially differ from the process observed in the primary development of bone.

Sixth. That the presence of the ensheathing and medullary callus, thought to be exceptional in man, should be considered the rule.

Seventh. That the terms *temporary* and *provisional* callus, as used by Dupuytren in contradistinction to the *definitive*, must be accepted with considerable limitation, the one not differing in any particular of composition from the other; that the delay in the production and bony transformation of the in-

termediate or definitive callus, as compared with the exterior and interior portions, is due only to the comparatively small vascularity of the compact part of the bone.

Eighth. That the complete absorption of the ensheathing callus never occurs, and that the re-absorption of the medullary callus is not a work of nature set in operation because the union at the ends of the bone has become complete, but is simply a repetition of the order followed in the development of the long bones, entirely independent of the fracture, a work which contributes both to their lightness and to their mechanical strength.

The time involved in the whole work of restoration varies no doubt in different persons, and is affected by various circumstances, such as the health of the patient, the quiet of the parts, and the accuracy of the adjustment. The process in its entirety may be described as follows:

First there is a period of rest,—one in which there is no visible attempt made to repair the damage. All seems quiet. Everything within the area of injury remains in chaotic confusion; and as an architect, before he begins the work of reconstruction, quietly surveys the mass of ruins of some noble building which has gone down under a sudden catastrophe, so the genetic forces of the parts seem to brood silently for a time over the scene of disorder before any note of preparation is sounded. This is of short duration, not generally extending beyond thirty-six hours. Following this comes a reactionary period, in which the ordinary phenomena of inflammation are present. There is an increased determination of blood to the part, accompanied by a transudation. This is sometimes very considerable, giving rise to much swelling and an exalted sensibility of the parts, and may continue for three or four days; so that the first five or six days are consumed in passing over the stages of local shock and inflammatory disturbance. It cannot be said that during this time any true reconstructive work has been inaugurated. In this respect the repair of fractures in lower animals, as chickens, rabbits, etc., differs from that in man. In the former the process of union is well established in seven or eight days. The acute symptoms having subsided, another period of three or four days elapses, during which a part of the inflammatory products, and a portion of the extravasated blood and other débris consequent upon the injury, are removed, and the tenderness and swelling, as well as the irritability of the surrounding muscles, become diminished. The vascularity, however, of the bone, periosteum, and endosteum does not diminish, but rather increases. From the eighth to the tenth day the real work of repair begins, that in which the true fibrogenous matter, swarming with cellular elements, assumes the appearance of order.

The differentiation of this constructive material into cartilage, or fibro-cartilage and intercellular substance, and the subsequent deposition of the bone-salts, ultimately permeating the mass and imparting solidity to the bone, are the work of four or five weeks.

Now, while we have divided this process into stages, allotting to each an approximate number of days or of weeks, it must not be supposed that these gradations are sharply defined, and that one cannot begin until the other is ended; on the contrary, they may blend or co-exist, and can only be regarded as approximately true; but they are nevertheless convenient for purposes of description.

In children union will often occur with great rapidity; and I have even known an adult with a fracture of the femur to rise from his bed and walk at the expiration of four weeks: indeed, I am convinced that the healing of fractures takes place at an earlier period than is generally believed.

Such is the ordinary mode of repair. It is alleged by some that where the apposition is very perfect, as where the fragments rest end to end or edge to edge, or where there is an incomplete separation of the fibres of the bone, immediate union may take place, just as it is alleged to occur under favorable circumstances in the soft parts. I have never seen any specimen which would induce me to adopt such a conclusion.

In compound fractures the existence of an external wound and the suppuration which ensues modify the plan of restoration. The work is greatly delayed, and the union is effected through a larger amount of granulation than in simple fractures, which, after its transformation into fibro-cartilaginous tissue, becomes incorporated with the lime deposits. In other words, the difference between the healing of simple and that of compound fractures is much like that between the healing of subcutaneous and that of open wounds.

In compound comminuted fractures the healing is still longer delayed. Detached portions of the bone die from losing their connection with the periosteum and the medullary tissue, and from the influence of the inflammatory products. The work of reparation is delayed until the sequestra are got rid of, after which granulations spring up abundantly from the medullary and periosteal tissues and undergo ossification. The time required for the separation of such necrosed portions may be so great that the restorative powers entirely fail, and no union will take place; or, if united, the connection is established in a large sheath of irregular callus, without any cohesion of the ends of the fragments to each other. It is in such fractures that we often find the hard and the soft parts extensively glued together by inflammatory lymph. Where there is loss of bone, in most cases there will be shortening, particularly in the adult, although, as shown by M. Ollier, the preservation of the periosteum will often provide to some extent against this, by supplying the material for partially bridging the gap.

When a cartilage is broken, the perichondrium behaves like the periosteum, furnishing the material for a bond of union, which consists not of cartilage, but of bone, and which envelops the parts like a firm ring, but often not filling the intermediate space, or that between the ends of the fragments. An epiphysis, when detached from its diaphysis, although the original conjunction was one of cartilage, will afterwards unite by bone; and as the bones grow in length by a deposit in the cartilage which exists between the ends of the shaft and the epiphyses, it has been stated that in such fractures the bone ceases to grow in the longitudinal direction. I have reason to doubt the correctness of this statement, believing that, although no increase in length may take place at the injured part, the failure is compensated for by increased activity in the nutrition of the intermediate cartilage at the other extremity. Fractures which extend through the articular incrusting cartilage seem to have no power to unite. There are other fractures which do not unite by callus. They are such as are subjected to the influence of the synovial fluid, or whose vascular supply is insufficient. Among these are fractures of the neck of the femur within the capsular ligament, of the head of the humerus, of the olecranon process of the ulna, and of the acromion process of the scapula. Fractures of the patella generally come under the same category.

Treatment of Fractures.—There is but one indication in the treatment of fractures, and that is to secure the union of the broken bone with the least possible deformity; and this single thought is to animate the surgeon during the entire management of the case.

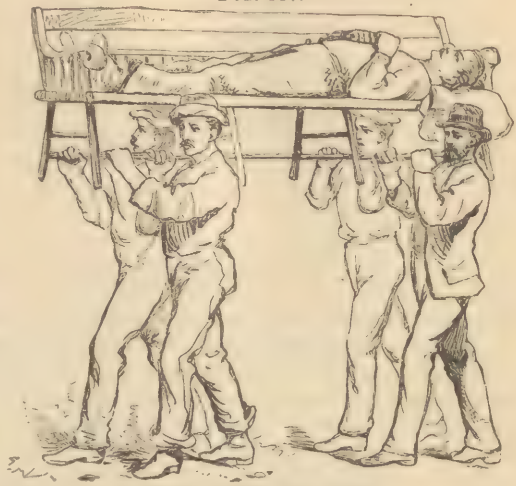
There is, however, involved in this, *first*, all that pertains to the transportation of the patient from the scene of accident to a hospital or a home; *second*, the preparation of the bed upon which he is to be placed; *third*, the adjustment of the parts,—that is, restoring them to their proper position, commonly termed *setting* the bone; *fourth*, the means for maintaining the parts permanently in place when adjusted; and, *fifth*, such local and general treatment as will remove or prevent all morbid processes inimical to the cure.

The transportation of the patient.—Injuries of this kind are very liable to occur when the patient is at a distance from home, in localities where buildings are in process of erection, or in manufactories or mines, and it becomes necessary to have the injured party conveyed either to his own residence or to a hospital. When it is an inferior extremity, the pelvis, or the spine, which has been broken, walking is, of course, out of the question.

Under such circumstances we may improvise a litter by taking a window-shutter, or a broad board, or a settee, which last is preferable to all others.

Whatever is used, it should be covered with a folded comfortable, and the patient laid upon it and borne to his destination by four or more persons, who are to keep step with one another, in order to avoid any irregular movements. (Fig. 587.) If the leg is broken, it should be placed on a pillow, which may be secured about the part with handkerchiefs or tapes. Where the distance is considerable, the patient may be transported on a bed or a mattress placed in a furniture-car, and in lifting him on or from the litter or the car, four persons will be required, two of whom should support the body by locking their hands underneath the thorax and the pelvis, a third should support the sound limb, while the surgeon or some intelligent person should always take charge of the damaged part, grasping it in such a manner as to insure an equable support, the seat of fracture resting on one hand. Where patients have to be sent long distances to a hospital, the limb should be surrounded not only with a pillow, but also with strips of light board, and these secured firmly about the part by handkerchiefs or cords. Where the upper extremity, the ribs, or the jaw are broken, a permanent dressing may at once be applied, if the means to do so are at hand. If not, then position and fixation are the chief indications. In the case of the maxillary bones, the jaws should be tied together with a handkerchief in cravat-form, the centre being placed under the chin, and the ends secured over the vertex; if it is the ribs that are fractured, the vest can be firmly drawn about the thorax; and if the arm, it can be suspended in a sling and fastened to the body.

FIG. 587.

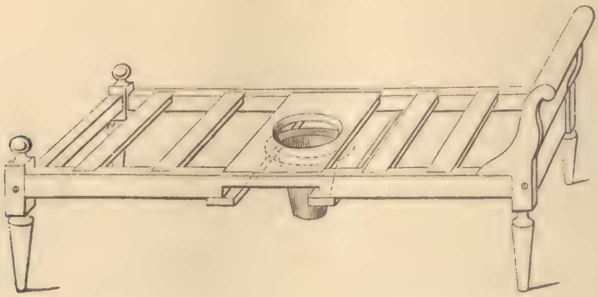


Bearing a patient upon a settee.

The preparation of a bed for all fractures of the lower extremities and of the spine is of the first importance. A firm mattress, tightly stuffed, which will not sink under the weight of the hips, is to be chosen, and a round hole cut out of the middle and lined with oil-cloth. The piece removed should be covered and hemmed or bound, in order to fill the opening in the mattress. The sheets require to have a hole corresponding to the opening in the mattress. The bedstead should be a narrow or a single one, making it convenient for the surgeon to approach his patient from either side. It should have a slat or a board bottom, the middle board being broad and having in it an opening corresponding to the one in the mattress. On each side of the wide board should be nailed a cleat or ledge, on which can be slid a tin or earthen vessel designed to receive the evacuations. (Fig. 588.) Most houses contain a single bedstead, which, with the aid of a carpenter, or by the handicraft of a surgeon, can very soon be modified so as to serve perfectly the purpose of a fracture-bed. In many localities the country practitioner is called to treat cases of fracture where the family is not able to purchase either a mattress or a bedstead, and he must utilize to the best advantage the resources at hand: it is a satisfaction to know that excellent results can be obtained in fractures of the thigh and the leg without either a mattress or a single bed. Under such circumstances, comfortables may be folded and placed together upon any bedstead until the requisite support is secured; or, if the

patient is old and the surface of the body tender, the ordinary feather bed, being first beaten out and flattened down, may be covered with the comfor-

Fig. 588.

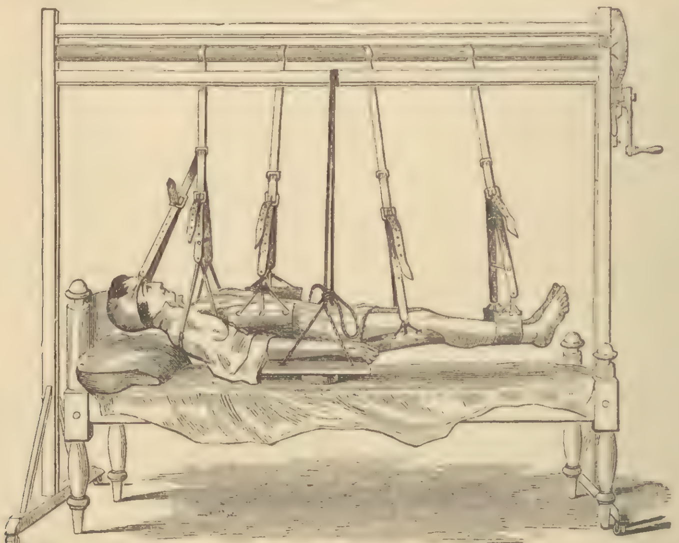


Fracture-bedstead made by altering the ordinary single bedstead.

tables. For receiving the dejections a bed-pan can be slipped under the nates from the sound side without materially disturbing the fracture.

Many ingenious fracture-beds have been devised, most of which are costly, and therefore limited in their use, such as the Jenks fracture-bed (Fig. 589), a

Fig. 589.



Jenks's fracture-bed.

kind of surgical derrick, rendered formidable by the amount of rigging needful for its effective operation. Beds have also been devised by Crosby, Hewson, Daniel, and others, but figure more in books than in practical use. Indeed, so far as my observation extends, both at home and abroad, very little importance is attached to the use of these contrivances. In injuries of the spine, or in cases of paralysis which are likely to prove tedious, in order to avoid bed-sores the air- or the water-bed is invaluable, especially the latter. Except, however, for those in good circumstances, this bed is too expensive.

Whatever bed is used, it must be covered with a sheet having an aperture corresponding to the one in the mattress. The removal of the soiled sheets and the substitution of clean ones require some notice at this point. This may be accomplished with the least disturbance to the fractured part by removing the pillow, pushing down the dirty sheet beneath the shoulders of

the patient, then placing over the uncovered part of the mattress the clean sheet, previously gathered into reversed folds. The upper part of this sheet is next to be smoothed down, tucked under the head of the mattress, and made additionally secure by placing upon it the pillow, while the lower part is to be fastened to the upper end of the soiled sheet with pins, the points of which should be directed upwards and buried out of sight. An assistant now raises the pelvis, while the patient, by making the back of the head a point of resistance, so elevates the body that the soiled sheet can be drawn down, bringing after it the one which is to take its place.

Removal of the clothing.—The bed being prepared, the next duty is the removal of the patient's clothing. A great deal of wastefulness and unnecessary destruction is often witnessed in effecting this. The coat, pantaloons, or boots are cut and slashed in every direction, rendering them for ever after useless. A coat may be removed, by a little gentleness and tact, without materially disturbing a broken bone; and so also may the pantaloons. Or, if difficulty is experienced, let them be opened along a seam. Even the boot, which is, perhaps, the most difficult to remove, can be taken from the foot of a broken leg by using it after the manner of a lever and coaxing it off, while counter-force to the leg is made by the hands of the surgeon.

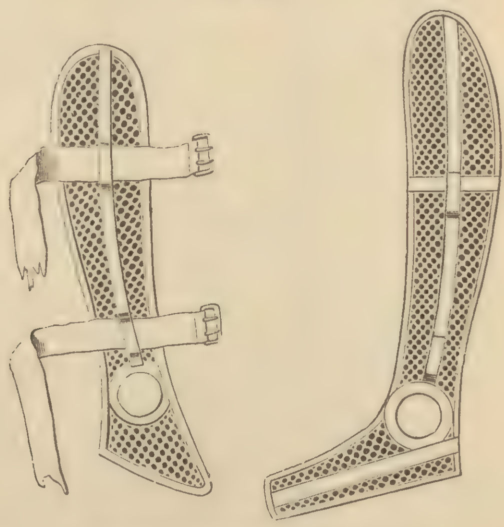
Retentive dressings.—The preparation of splints for maintaining the fracture in position when adjusted becomes the next duty. While I do not undervalue the ingenuity and zeal of those who are devising neat and elegant appliances for the treatment of fractures, it is nevertheless desirable that whatever dressings are employed should be simple and always accessible. The more complicated and elaborate the splint, as a rule, the more limited is the experience of its inventor in dealing with the class of injuries under consideration. With a view to furnish the needful lateral or antero-posterior pressure, various materials may be used, such as light poplar or pine boards, binders' board, gutta-percha, sole-leather, tin, zinc, felt, wire, and plaster. When light strips of wood are used, they must be padded with cotton, oakum, or old pieces of blanket, which, after being laid upon the surface of the splint, can be made fast by the turns of a roller.

Binders' board answers in many cases an excellent purpose. A pattern of

Fig. 590.

Splint formed out of binders' board.

Fig. 591.



Splints prepared from perforated tin and zinc.

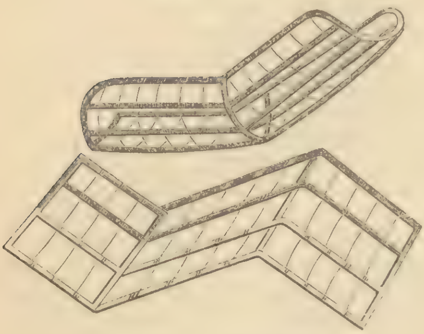
the part to be supported should first be cut out of paper, and after this model the form of the binders' board can be fashioned. Before its applica-

tion, the material must be dipped in hot water until it is thoroughly softened, when it can be moulded to the part with great accuracy (Fig. 590), the limb being previously protected by a thin sheet of cotton wadding.

Tin and *zinc* splints (Fig. 591) were used during the War of the Rebellion, having been introduced into the army chiefly through the influence of Dr. Harris, of New York.

Wire splints (Fig. 592) have been recommended by Dr. Nott, of Mobile, and also by Dr. Louis Bauer.

FIG. 592.



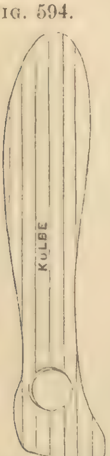
Splints prepared from wire.

FIG. 593.

Dr. Ahl's felt splints.

A felt splint has been prepared by Dr. Ahl, of Pennsylvania, which is admirably adapted to the treatment of fractures. (Fig. 593.) This material is porous in its texture, and requires to be dipped into hot water or to be held before an open fire in order to render it soft and pliable, after which it can be moulded to any surface or at any angle. Its form and firmness are not affected in the least by cold water. Its value, moreover, is not impaired by having been previously used. It can be again rendered flexible by a second immersion in hot water, and adapted to another part. This material is also porous, so that the part, if it were desired, could be kept wet with cold water without affecting the fixed form of the splint.

FIG. 594.



Wooden slats pasted to sheep-skin; opening made for the malleolus.

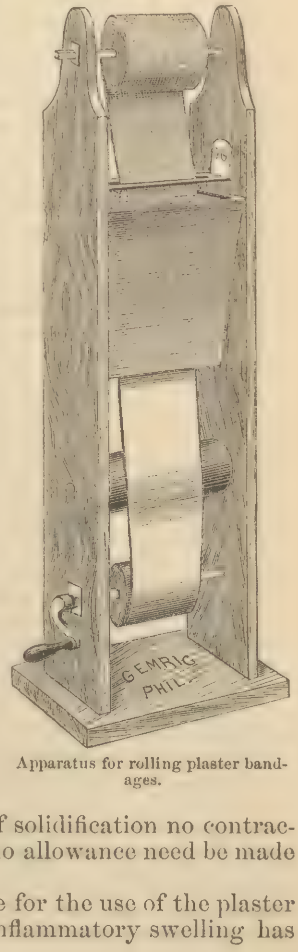
Thin slats of light wood, pasted or glued to sheep-skin leather (Fig. 594), are sometimes used when it is desired to distribute the support equally about the limb. Openings can be cut in the splint so as to admit salient points of the skeleton.

Immovable dressings are such as are designed to be permanent, or to be removed only at considerable intervals of time. The materials employed for this purpose are quite numerous. Seutin, in 1834, used clear-starch for the purpose of rendering the dressing hard. His plan of applying the bandage was, after protecting the bony prominences of the limb with cotton, to encircle it with a number of rollers, each brushed over with the starch. Between the bandages strips of pasteboard were interposed in order to increase the strength of the dressing at particular points. After the "appareil" became hard, it was slit up along the front, so that the condition of the limb could be ascertained at pleasure, and the dressing was afterwards bound together with a roller. The "apparatus immobile" is really much older than Seutin, having been used at a very early date by Albugene, an Arabian sur-

geon. Other materials are in common use as substitutes for starch, such, for example, as dextrin, the silicate of soda or liquid glass, a mixture of pounded chalk and gum arabic reduced to the proper consistence by boiling water, also gum-shellac. Flour formed into a paste with water or the white of eggs constitutes another useful mixture to stiffen the materials with which a fracture is surrounded. It is not necessary, in order to apply the immovable dressing, that rollers should be exclusively used. The part may be enveloped in a piece of cloth or bed-ticking, or a blanket, or the leg of an old pair of pantaloons, or a soft felt hat, any one of which can be rendered sufficiently firm by soaking it with one of the mixtures mentioned above.

Plaster of Paris is very justly esteemed as among the most valuable and easily managed forms of an immovable fracture dressing. This material is most conveniently employed in the form of rollers,—first brought to the notice of the profession, in 1852, by Mathiesen, of Holland. It is only, however, within the last twelve or fourteen years that this dressing has received in this country the attention to which it is entitled. During the War of the Rebellion it constituted usually a part of the ambulance supplies. It has been extensively employed in the treatment of fracture in Bellevue Hospital, New York, receiving the high commendation of Professor Hamilton, and in the University Hospital of this city it forms one of my established dressings for the same class of injuries. The plaster roller is formed by taking strips of crinoline of the proper length and breadth and filling the interstices of the fabric by drawing the bandage through the plaster, and at the same time rubbing it in with the hand and rolling the strip as it is filled into a loosely-formed cylinder.

Fig. 595.



Apparatus for rolling plaster bandages.

A very convenient apparatus is in use for the formation of plaster rollers, which consists of a base with two upright pieces. Between the latter is a box or hopper, which is filled with the plaster, and through which runs the strip of crinoline, previously wound on an iron rod above, and which is rolled upon an axle having a handle below. (Fig. 595.) These rollers, when once formed, should be packed in tin boxes, or, if placed in an ordinary box, should be surrounded with waxed paper or with oiled silk, in order to exclude the moisture of air, the presence of which tends to destroy the hardening quality of the plaster.

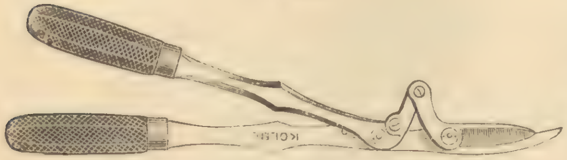
In applying this or any other form of the immovable dressing, the limb should be first surrounded with a dry bandage. The plaster roller, when used, having been previously dropped for two or three minutes into a basin of water, should be gently squeezed, and then applied in circular and spiral turns, ascending and descending the limb until the requisite number of rollers, usually three or four, has been employed. During their application, the hand of the dresser should be occasionally dipped into water and passed over the bandage, in order to smooth down the plaster which accumulates on the surface. In a few minutes the roller begins to harden, and at the expiration of half an hour it is quite solid. During the process of solidification no contraction takes place in the dressing, and consequently no allowance need be made for shrinkage.

The period which I regard as the only proper one for the use of the plaster roller in the treatment of fractures is after the inflammatory swelling has

subsided, and when the surgeon can calculate on the fixed dimensions of the part. If used earlier than this, the limb will most probably, in a few days, lie loose in its case, the patient being thus exposed to the risk of an ununited fracture, or if the swelling is on the increase the dressing may, in consequence of its unyielding nature, jeopardize the vitality of the extremity by interfering with its circulation.

In order to open any form of the *appareil immobile*, it will be necessary to use a pair of strong cutting pliers. (Fig. 596.)

FIG. 596.



Von Brun's cutting pliers.

Bags and pads.—In fractures, especially of the lower extremity, strong muslin bags, filled with bran, or with sand, are frequently used, designed either to protect the limb against the pressure of the splints, or to supply lateral support to the broken bone. (Fig. 597.)

A feather pillow is well suited to give the requisite posterior and lateral support in fractures of the leg when the fracture-box is employed as a dressing.

Muslin rollers constitute another indispensable dressing, and when applied with proper judgment are invaluable. They should pass from the distal towards the proximal extremity of the limb with an even and uniform pressure. If these directions are neglected, the roller becomes one of the most dangerous appliances of our art.

FIG. 597.

Bran bag.

Adhesive plaster forms a valuable addition to our mechanical resources. To Dr. John K. Swift, of Easton, Pennsylvania, we are indebted for its introduction as a fracture dressing as early as the year 1830; and still later, to Professors Samuel D. Gross, Gilbert, Wallace, and Neill. As a means of extension in fractures of the long bones of the lower extremity, it was first used by Dr. John Swinburne, of Albany.

Other materials have been employed at different times as fracture splints, among which may be mentioned Manilla paper, recommended by Dr. Cowling, of Louisville, Kentucky. In its application, the paper should be cut into strips, and, after being soaked with starch, should be laid upon or made to surround the limb.

Even the bark of a tree, if removed during the flow of the sap, may be used as a fracture dressing, as suggested by Dr. Jacobs, of Dublin, Ireland.

Setting the fracture.—The mechanical appliances being at hand, the next duty is the proper adjustment of the bone, commonly called *setting the fracture*. In many cases this can be readily done by the surgeon alone, as in fractures of the bones of the forearm, or in those of the leg, the ribs, and the jaw. In other fractures, as those of the thigh, an assistant may be required.

The application of force necessary to effect this object is threefold, viz., by *extension*, by *counter-extension*, and by *coaptation*.

Extension is applied to the distal extremity of the limb, and consists in pulling the lower fragment into its proper relation with the upper one, and is necessitated by the existence of overlapping in the broken ends of the bone. As a rule, the farther removed the extending power is from the broken bone, the better: for example, drawing upon the hand or upon the

foot, in a fracture of the arm or of the thigh, is better than making traction near the injured part, as the muscles are thereby measurably relieved from the stimulus of pressure, which serves to provoke resistance. A displaced tendon, or the locking or impaction of the fragments, may obstinately oppose the restoration, though this is generally resisted by muscles, which are often goaded into a state of great irritability or spasm by the sharp ends of the fracture, or by painful pressure upon a nerve. Hence it becomes necessary to disarm the muscles of their opposition as much as possible, by placing the part in such a position as will secure their relaxation, after which, by making the extension gradually and continuously, they may be wearied or coaxed into submission. Should these measures fail, the exhibition of an anæsthetic will readily overcome the difficulty.

Counter-extension is to be applied so as to fix the proximal fragment, and must counterbalance the extending power, the two forces pulling the fragments from each other. Counter-extension should also be made in such a manner as not to irritate the muscles of the injured limb; that is, it should be applied as remotely from the seat of fracture as may be consistent with efficiency. In many cases there is no displacement, and therefore these manipulations are unnecessary.

Coaptation consists in making such pressure, counter-pressure, and manipulation as will press the fragments into their proper relations with each other, and must be done by the fingers of the surgeon. In these different acts the greatest gentleness, delicacy, and precision should be observed, so as to inflict as little pain as may be compatible with the adjustment. This being satisfactorily accomplished, the dressings necessary to maintain the advantage gained should be next applied.

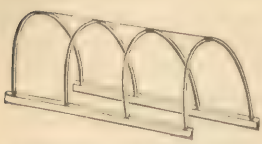
The time to set a fracture.—There ought to be no difference of opinion on this point. No advantage can result from delay, and therefore the sooner the work is done the better. Delay enhances the difficulties, and involves increased pain and suffering. The parts become swollen and sensitive,—conditions which complicate the examination; the muscles offer greater resistance, and the inflammation is intensified by the force required for the reduction.

After-Treatment.—After a fracture is dressed, it may be necessary, if the patient complains of pain, becomes nervous, or is disturbed by muscular spasms, to administer an anodyne, either by the mouth or hypodermically. One-fourth of a grain of morphia injected beneath the skin, if the patient be an adult, will generally secure, in a few minutes, relief from suffering.

After the lapse of twenty-four hours the dressing should be renewed, at least in all fractures of the upper extremity. The necessity for such a course arises from the swelling which follows the injury, and which may become both painful and dangerous, from the resistance of the bandage. The removal of the dressing also enables the surgeon to see if any displacement remains or has occurred since it was first applied. He should visit his patient again on the second day, and if the bandage is found uncomfortably tight, renew it as on the former visit, but if not, it is better that it should remain undisturbed. Indeed, from this forward the less meddling the better, and he should interfere only when the dressings become loose or in any way disarranged, or when it is necessary to make passive motion of a joint. Anything more than this is pernicious. If the system at large becomes perturbed, and traumatic irritation or fever ensue, the diet should be restricted for two or three days, the bowels regulated with a mild saline, as a Seidlitz powder, followed by the neutral mixture, each dose of the febrifuge containing about one-twentieth of a grain of morphia. The state of the bladder must not be overlooked, and if the patient is unable to expel the contents of this viscus they should be removed by the use of the catheter. In six or eight days, ordinarily, all disturbance has passed over, and the visits of the medical attendant may be made at longer intervals, namely, on every second day, and finally every third day. In fractures of the upper extremity, of the ribs, and of the jaws,

the patient is in most cases, after a few days, able to walk about, and need not, therefore, be confined to the house. If the lower extremity is broken, it will be necessary to support the weight of the superincumbent bedclothes by the "cradle" (Fig. 598), or by a substitute, which can be quickly constructed by tying the segments of two hoops together.

Fig. 598.



Fracture-cradle for supporting the bedclothing.

The disuse of a joint is soon followed by rigidity or stiffness; and as it is necessary in the management of a broken bone to maintain for a time the absolute rest of the part, such a condition may naturally be anticipated, should the fracture be one of an extremity. On this account, after a period of from eight to twelve days, gentle movements of the contiguous articulations must be made, which are to be repeated at each renewal of the dressings. The nutrition of the parts involved in a fracture is also modified, and hence the dry condition of the skin, with the accumulation of epithelial débris. Nothing gives more comfort or produces a better capillary circulation under such circumstances than brisk friction with alcohol, applied with a sponge. Where the patient is obliged to remain on his back, as in fractures of the lower extremity, care must be observed to prevent the occurrence of bed-sores, by frequently inspecting those portions of the body which sustain the greatest degree of pressure, and rubbing them with alcohol. Should the skin become inflamed, it may be covered with adhesive or with soap plaster, and in addition may be further relieved by the use of properly-prepared cushions or fenestrated pads.

Time to lay aside the dressings.—In fractures of the upper extremity, the splints may be permanently removed in from four to six weeks. The arm, however, should be carried in a sling for two or three weeks longer, in order to remind the patient that it is not yet sufficiently strong to endure any great amount of muscular force. He should himself practice the various movements of the joints of the limb, in order to restore their proper suppleness. Where the injury has been in the course of the lower extremity, a longer time must be allowed before the splint or splints are laid aside, say from five to eight weeks, and when the original dressings are removed, it is prudent to substitute, particularly in the case of the thigh, or of both bones of the leg, a plaster bandage, or, if this be not at hand, light binders' boards can be moulded to the parts and fastened by a roller. These directions apply to the ordinary progress of fractures. There are others, fortunately exceptional, in which no time can be specifically laid down for the removal of the splints, as where the union is tardy or delayed, or where the callus itself is defective.

Thus far we have been dealing with simple fractures. Let us next consider those which present certain complications.

Compound fractures.—In such, a communicating wound is present, which makes the point of departure, and which, insignificant though it may be, gives a serious character to the injury, and often necessitates the loss of the limb. This complication is often followed by suppuration, which extends through the components of the limb, disorganizing the soft parts, destroying the vessels of the bone, and inducing necrosis. Or, by its long continuance and profuseness, it may wear out the patient, or may kindle into fatal activity some latent predisposition to disease which had quietly lurked in the body. Pyæmia and erysipelas are also among the evils which frequently follow in the train of an open fracture. In undertaking the management of such a case, the first question to be settled is that of amputation. This negatived, then comes the treatment.

As the evil consequences of this injury seem to depend on the presence of a communicating wound, our efforts should be directed to its closure, if possible, thus changing the conditions to those of a simple fracture. This state-

ment, however, is to be accepted with some qualification. If the opening is quite small, it is always proper to seal it up. This may be done by covering it with a strip of adhesive plaster, by applying silk gauze and collodion, or by utilizing the blood which oozes from the orifice of the wound, favoring its coagulation and scabbing, and by placing upon the opening a little charpie or lint and preventing its displacement by drawing over it a piece of adhesive plaster. The antiseptic dressing of Lister may be employed for the same purpose. If the opening, however, is large, we can scarcely hope to secure union; suppuration will almost inevitably follow, and, if the wound be tightly closed, great structural damage will be done by confining the purulent and other inflammatory products in the limb. If, therefore, any attempt is made to seal up such a wound, it cannot be too carefully watched, and it should be freely opened on the earliest manifestation of the presence of pus. In general, I believe patients will be better off if no attempt whatever is made to close permanently such a wound, especially if it has been produced by the force which breaks the bone, thus contusing the tissues and favoring suppuration.

In cases where one or both broken fragments protrude, they must be restored to their proper position by extension and counter-extension, placing the limb at the same time in such a position as will relax its muscles and thereby favor this result. If the edges of the wound resist the reduction, they should be drawn asunder with retractors, or, if this is not sufficient, the opening may be enlarged; and finally, if these means prove unsuccessful, as a last resort—but only as a last resort—the ends of the bone may be removed with a saw, observing to cut away no more than is absolutely necessary to effect the reduction. In doing this, the soft parts should be protected by interposing between them and the bone a piece of leather or a thin piece of light wood.

A compound fracture may be further complicated by *comminution*, in which case there will be three or more fragments, or the bone may be splintered. These splinters sometimes are completely detached, or shelled out of the periosteum, and when separated from their vascular connections are likely to die; on which account they should always be removed. Sometimes their attachments are not entirely severed, yet the fragment proves quite loose. In this case the piece had better be removed; for, if this is not done, its presence will delay the union,—may even defeat it,—or, if not, the future suppuration will in all probability insure its death and render its subsequent extraction necessary. Especially is it proper to remove such splinters when contiguous to a joint or to a cavity of the body. Where osseous fragments maintain their vital connections and are not very loose, they had better be adjusted and allowed to remain, as nature will often unite them solidly with the other parts of the fracture. In fractures of the bones of the face, even very loose portions should be preserved, as the great vascularity of this part of the skeleton justifies a more conservative course than elsewhere.

There is, particularly in simple fractures, almost always some ecchymosis. In compound fractures it is not so common, because the blood escapes from the external wound. It may spread over the greater part of a limb, so as to resemble gangrene. Vesication may occur also. As to ecchymosis, time will effect its removal, though this may be hastened by applying some dilute alcohol to the surface and thereby stimulating the vessels to increased activity. The blisters, when present, should be punctured at two or three points with a fine needle, so as to allow the escape of the serum without removing the cuticle, and then over all may be applied a light dressing of zinc ointment.

Hemorrhage after simple fractures.—It is possible in a simple fracture, attended with much displacement, for the main artery of a limb to be torn by the sharp extremity of one of the fragments. This accident must be regarded as a serious occurrence, and will be indicated by the rapid swelling of the limb, the presence of pulsation in the tumor, and the cessation of the

pulse in the arterial branches below the seat of injury. The course to be adopted in such an event is to command at once the circulation of the limb by applying a tourniquet, and then proceed to ligate the main artery of the limb at the point of election. Should the collateral vessels be equal to the task of re-establishing the circulation, the arteries below will resume their pulsation, and the heat and sensibility of the limb will return, when a favorable termination of the case may be anticipated. If gangrene sets in, the sooner amputation is done the better.

Hemorrhage after compound fractures may be either *primary* or *secondary*. When primary, it may come from the vessels of the bone, and will generally cease after the reposition of the fragments and the application of pressure; or it may have its origin in a torn vein or artery external to the bone. If from a vein, the bleeding will be checked by pressure over the wound: even with veins the size of the femoral or the brachial, when so injured, this course will be proper. When the hemorrhage comes from a torn artery and proves persistent, the external wound should be enlarged, and the vessel searched for and tied. If this cannot be effected, the artery of the limb must be exposed and tied above, at the point of election. The exceptions to this course will be in compound fractures of the thigh, complicated by laceration of the femoral artery, and in similar injuries of the leg, in which both the anterior and posterior tibials are torn. Under such circumstances amputation is imperative. A lesion of both the radial and ulnar arteries in a compound fracture of the arm, unattended with any extensive damage to the soft parts or comminution of the bones, would not justify the removal of the limb, as the numerous vascular communications of this part are capable of maintaining its life even under very serious mutilations.

When the bleeding is secondary,—generally the result of sloughing,—the offending vessel should be sought for and tied in the wound, if not controllable by pressure; and if the hemorrhage is repeated with sufficient severity to endanger the life of the patient, the limb should be promptly removed.

The dressing for compound fractures will be described with that of other fractures.

Injury of large nerves may produce great feebleness of the limb, and even complete paralysis, but will not necessarily defeat the union of the bone. This fact has been well established, both by experiments on the lower animals and by observations on the human subject.

Compound fractures of joints.—When the joint implicated is one of magnitude, as the knee, the hip, the shoulder, the elbow, or the ankle, the case is always a grave one. The knee-joint, being extensive and complex, is, of all, the most intolerant of injury; involvement of the wrist or of the ankle is also serious, though in a less degree, so that compound fractures of these articulations will in a great majority of instances demand amputation or excision, while such as involve the ball-and-socket articulations, and perhaps the elbow-joints, if the surrounding soft parts be not too extensively mutilated, will be best treated by excision. Should the main artery be torn, in addition to the joint injury, amputation must be done at once.

Fractures not compound extending into a joint.—These may be properly considered as complicated. Such a joint is spoiled in some degree. Abridgment of movement must be expected, but to what extent it is impossible to foresee. It may result in permanent anchylosis. I have seen it end in the loss of the limb. The accident must be treated as an ordinary fracture. Should inflammation of the articulation arise, it must be promptly met by local antiphlogistics, and as soon as possible passive movement must be cautiously practiced, in order to preserve, if possible, the function of the joint.

Fracture with dislocation.—In such a complication, the fracture is to be properly supported with splints, and afterwards an attempt made to restore the luxation. Should the fracture be near to the displaced articulation, particularly if a ball-and-socket joint, it is not probable that the dislocation will

be reduced. Nor have the attempts made to restore the luxation after the consolidation of the fracture been followed by any encouraging degree of success. In such cases it only remains, after the union of the bone, to establish as much movement as may be possible with the malposition of the parts. In fractures accompanied with the luxation of a ginglymoid joint, reduction of the articulation may be effected.

A compound fracture associated with luxation sometimes occurs, accompanied with such extensive damage to the soft parts as will require the amputation of the limb. In such a case the dislocation should be first restored, if possible, and subsequently the operation be performed.

Fractures are frequently met with in limbs which have been contracted by the cicatrices of burns or which are permanently flexed by anchylosis. Such conditions do not materially influence the result, as the splints can be adjusted to the angularities of the part.

In a case of fracture affecting the femur, where a bent anchylosed knee-joint exists, we have it in our power to correct the disability by securing union of the fragments at a proper angle. I have in three cases availed myself of this coincidence, and given the patients useful limbs.

Necrosis frequently follows compound fractures, especially if there exists the additional element of comminution. The detachment of the periosteum at the time of the accident, or subsequently, by the suppuration, and the disturbance to the medullary tissue, are quite sufficient to account for this. The treatment does not differ from that appropriate to necrosis from other causes. The surgeon must wait until the sequestrum is well separated,—a fact which he ascertains by testing its mobility with a stout probe. When the dead portion is loose, it must be removed by enlarging the wound or the sinus and cutting away with a chisel such callus, or other bone, as may oppose its extraction.

Mania a potu.—In persons much addicted to the use of alcoholic drinks, the existence of a fracture will often induce an attack of delirium tremens. Under such circumstances the greatest care must be observed to prevent the ends of a simple fracture from being driven through the skin, or of a compound one from passing out of the wound. It will be necessary to place a strait-jacket on the patient, or to secure the arms and body to the bed. A pillow may be secured firmly around the seat of fracture; or what answers better than any other plan, is to mould to the limb two pieces of binders' board, interposing plenty of cotton, and making them secure with a roller bandage. This will prevent any serious damage to the parts until, by appropriate treatment, the delirium is cured, when the fracture can be dressed permanently.

Epilepsy.—In aggravated cases of this disease, much difficulty may be encountered from the muscular spasms disturbing the needful quiet of the fracture. A protective dressing like that for delirium tremens, and full doses of bromide of potassium, constitute the best remedial measures. In connection with these irregularities of muscular action, an interesting case is related by Dr. William Hunt, of the Pennsylvania Hospital, of fracture of the humerus, in a patient suffering from chorea, in whom it was impossible to keep the fragments fixed. The unfortunate man died, being finally worn out from sheer exhaustion.

Anchylosis.—This depends upon a variety of conditions. When the fracture is near to a joint, doubtless the stiffening is due to inflammatory deposits within the articulation; but generally the rigidity is simply the result of immobility, in which state the muscles and ligaments become shortened and inelastic from the absence of that moisture which is normally present among their fibres. The synovial secretion is also less abundant. When the stiffness is not very great, frequent movements by the physician, or by the patient himself, accompanied with douches of water, kneading, and friction, will commonly restore the usual flexibility; but when the pain of such

manipulation cannot be endured, and when it is requisite to employ considerable force in order to overcome the resistance, such movements should be made only after exhibiting an anæsthetic.

Ununited Fracture, or Pseudarthrosis.

A fractured bone may not unite, to which condition we apply the term *ununited fracture, non-union,* or *pseudarthrosis.*

It is necessary, however, to draw a distinction between a temporary and a permanent failure to unite. Delayed or tardy union is no uncommon occurrence. The fact that on examining a fracture after the usual period of treatment has elapsed, the consolidation is found to be imperfect, is no evidence that union will not follow at a later date. If, however, the ends of a broken bone remain movable five or six weeks after the time commonly consumed in the repair of such injuries, it is fair to infer that the case has become one of non-union.

CAUSES.—The causes which conspire to produce this condition are both constitutional and local.

The *constitutional causes* are, in general, all such as tend to depreciate or diminish the vital powers of the system, as hemorrhage, an attack of fever, exhausting diarrhœa, or defective nutrition. *Shock,* in a number of instances, I have found to retard the consolidation of fractured bones.

Gestation and *lactation* are said to exercise a retarding influence upon the work of osseous repair. The enormous amount of blood attracted to the uterus during pregnancy might be expected to lessen in some measure the active process of osteogenesis.

Scorbutic disease has not only retarded the formation of callus, but has been known also to produce its absorption after the bone had become united. I have seen a fracture of the thigh which had become well consolidated open again in consequence of an attack of delirium tremens inducing the resorption of the reparative material.

Advanced age has been reckoned among the causes retarding bone repair, but it probably exerts little if any influence of this kind. In a lady ninety-five years of age, whom I attended for a fracture of the thigh, the union took place at the usual period. All the cases of ununited fracture which have come under my own observation have been under forty years of age, and Amesbury, who had seen about ninety cases, states that none of the patients were past middle life. Twice have I witnessed congenital pseudarthrosis in the bones of the leg.

Syphilis, cancer, and *rheumatism* have each been charged with being inimical to the development of callus, but without any sufficient facts to establish the statement.

Paralysis, affecting as it does both the vascular and the nervous endowments of a part, may possibly interrupt the process, though the cases in which this occurs are exceptional.

Local causes.—Under this head comes everything which disturbs the quietude of the fracture, or provokes undue inflammation at the extremities of the fragments.

It has been supposed that the destruction of the nutritious artery has a tendency to retard and not unfrequently to defeat the repair. The cases collected and analyzed by Guéretin would appear to favor this opinion, though the tables of Norris are adverse to such a view. In most instances of delayed union, and especially those of non-union, which have come under my own observation, the cause could be traced to certain influences, among which may be mentioned the presence of a foreign body, as a fragment of necrosed bone, or a ball. Not unfrequently the failure to unite arose either from a defect in the apparatus employed as a dressing, which failed to secure the perfect immobility of the fragments, or in consequence of the restless and refractory disposition of the patient, who would clandestinely take un-

warrantable liberties with the limb and the splints in the absence of the medical attendant.

On the other hand, cases will occur in which a fracture refuses to unite notwithstanding the most faultless management, and even when the constitutional vigor of the patient appears to be unimpaired.

While movement in the ends of a broken bone is to be deprecated, it should not be forgotten that too great a constriction of the limb by tight bandages may so embarrass the circulation as to arrest the process of repair.

It is said that in hospitals where the immovable dressings are employed from the beginning in the treatment of fractures, cases of tardy union and of non-union are most common. If such is the case, I am disposed to attribute the result not to the immobilization of the limb, but to the very reverse condition, namely, the imperfect manner in which the part fills the dressing after the subsidence of the inflammatory swelling, thus allowing too much mobility.

The bones in which non-union is most frequently met with are the humerus, femur, tibia, ulna, inferior maxillary, and clavicle. The interesting tables of Dr. George Norris furnish 150 cases occurring in the femur, 48 in the humerus, 19 in the forearm, 33 in the leg, and 2 in the lower jaw. According to my own experience, this condition is most common in the femur, next in the humerus, and next in the tibia. A very strong argument in favor of the local origin of non-union is to be found in the rarity of such a condition in hospitals where the patients are under strict supervision and skillful management. In 946 cases of fracture treated in the Pennsylvania Hospital during twenty years—from 1830 to 1850—not a single case of non-union occurred; and from 1850 until 1874, during which period 6480 fractures were treated in that institution, no false joint, so far as I can learn, took place. In the Massachusetts General Hospital, Boston, according to Dr. Moreland, only 1 case in 367 fractures was seen. Lonsdale states that in 4000 cases treated in the Middlesex Hospital, London, only 6 instances of non-union were recorded. Hamilton estimates 1 case in 500 fractures.

FIG. 599.

Ununited fracture, in which the ends of the fragments have been rounded.

FIG. 600.

Ends of an ununited fracture connected by fibrous tissue.

FIG. 601.

Ununited fracture simulating a ball-and-socket joint.

When a fracture fails to unite by true callus, the ends of the bone undergo various changes.

First. They become, under the action of the vessels, rounded or conical, and incrusted with a fibrous or fibro-cartilaginous structure, without any intermediate connection. (Fig. 599.)

Second. The ends may become united to each other by one or several bands of fibrous tissue more or less elastic, which union limits, in some degree, the mobility of the parts. (Fig. 600.)

Third. The ends may be rounded and eburnated, or they may be incrusted with dense fibrous tissue, or even cartilage, and inclosed in a firm capsule of fibrous tissue, the interior of which has a smooth and glistening appearance and furnishes a lubricating fluid somewhat analogous to the synovial. This

sac is doubtless formed as are the bursal cushions in club-foot. This form of non-union answers to the true *pseudarthrosis.*

Fourth. The end of one fragment may be rounded, and that of the other excavated, both being inclosed in a capsular ligament or sac, the interior of which is lined by a bursal membrane, the whole closely resembling a ball-and-socket joint. (Fig. 601.) A very perfect example of this variety I once witnessed in the humerus of a patient who died at the Philadelphia Almshouse.

Fifth. The extremities of the fracture may or may not expand, and afterwards become surrounded with a considerable amount of granular callus, while the ends remain separate and movable. (Fig. 602.)

Fig. 602.

Ununited fracture of the tibia, the ends of the fragments being surrounded with callus.

In some very rare instances the bone, instead of assuming any of the above conditions, undergoes absorption. A case of this nature is recorded in the "Boston Medical Journal," in which a boy eighteen years old had the humerus broken. The bone, after the accident, was entirely absorbed, the remaining components of the arm continuing unchanged except in form. Professor Gross relates a similar instance in a man fifty-three years of age, where, with the exception of its head and condyles, the humerus wholly disappeared. During the winter of 1875 my attention was called to a case of ununited fracture of the humerus of eight years' standing, in which one-half of the humerus had disappeared.

Treatment.—In many cases of tardy union, all that will be required is to immobilize the fragments thoroughly by the plaster or the silicate of soda dressing. This will enable the patient to walk about in the open air with or without crutches, according to the bone affected, or, if this is not feasible, at least will admit of out-door exercise in a wheeled chair, and thus avoid the tedious and depressing influence of long confinement. Three or four weeks' perseverance in such a treatment will generally secure the cure.

In the management of these cases of delayed union, the general condition of the patient must not be overlooked. If the system is enfeebled, the diet should be improved and varied, and tonics should at the same time be administered, as the tincture of sesquichloride of iron, the compound tincture of cinchona with dilute phosphoric acid, or a combination of the phosphates when the case is one of true ununited fracture.

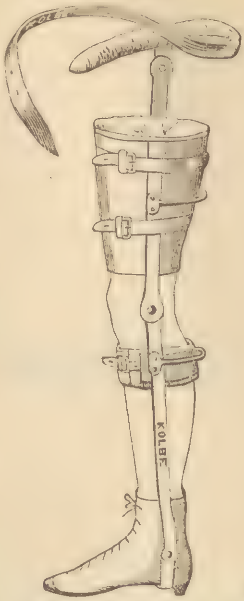
Various measures have been suggested and practiced for the cure of false joint. They are all designed to produce such an amount of irritation as will invite an increased afflux of blood to the part, and thereby favor the production of callus. They may be arranged under the following heads:

Friction.—This is perhaps the oldest method, and was practiced by Celsus. If the ends of the bone have not been materially changed, it will often succeed, particularly if the case is only one of delayed union. The operation consists in removing the dressing, seizing the limb above and below the seat of fracture, and rubbing the fragments forcibly against each other. The limb is then to be put up with the greatest care in an *immovable dressing*, so as to secure the most complete quietude. The dressing may afterwards be slit up and sprung open, so as to admit of its being disengaged from the limb, if it is deemed necessary to repeat the friction a second time.

A second method of applying friction is one which subjects the ends of the bone to a continuous, not a temporary, rubbing, and at the same time secures them against displacement. For this purpose, White, of Manchester, constructed an accurately-fitting leather case for the thigh, which furnished such a support to the parts that the patient could move about and receive the benefit

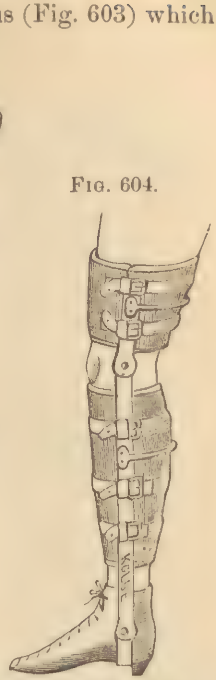
of fresh air. Professor H. H. Smith employs an apparatus (Fig. 603) which more perfectly than any other, fulfills these ends, and has been successful in several cases in effecting perfect cures. The same principle can be carried out by mechanical appliances in the treatment of ununited fracture of the bones of the upper extremity. The apparatus of Hudson, manufacturer of artificial limbs, New York, acts somewhat in the same manner. It is a hollow cone composed of willow, secured to the limb by straps and buckles, and furnishes a very equally-distributed pressure. If, however, any walking apparatus is employed, that of Professor Smith, as modified by Kolbe, fulfills most perfectly the end in view.

Fig. 603.



Smith's apparatus for ununited fracture of the thigh.

Fig. 604.



Smith's apparatus for ununited fracture below the knee.

External irritation.—Walker and Brodie recommended for this purpose the use of blisters. Stimulating friction with various liniments has been employed for the same purpose. Cline the younger was in the habit, at St. Thomas's Hospital, of establishing an issue over the seat of fracture with caustic potash,—a practice which was imitated by Drs. Hewson and Hartshorne. These applications have passed out of use. Little good could be expected from such agents, as the point of irritation designed to attract the blood was too remote from the seat of fracture.

Subcutaneous irritation.—This was accomplished in various ways. Irritating substances, such as nitric acid, caustic potash, nitrate of silver, or tincture of iodine, were introduced through a canula, so as to act directly on the ends of the fragments. These materials were designed to destroy the dense incrustation on the ends of the bone, and to cause such a degree of inflammation as would secure the deposition of callus. Another method of effecting the same result was by acupuncture, or the insertion of long, delicate needles through the soft parts and between the fragments, as practiced by Mr. Birch, of London, and also by Malgaigne and Wiesel. Lente, of New York, has conjoined electricity with acupunture. He inserts needles, one upon the end of each fragment, and then attaches to these the poles of a battery. Successful cures have been effected by this plan. Subcutaneous scarifications have been made by introducing a tenotome and cutting in various directions through the adventitious formation attached to the bone. Miller, of Edinburgh, succeeded in curing five cases by this method; and Sanford, of Iowa, reports two cures by a similar procedure.

The seton.—In 1802, Dr. Physick employed successfully the seton in a case of ununited fracture at the lower end of the humerus. This specimen is at present in the Museum of the Medical Department of the University of Pennsylvania. (See Fig. 605.) The material used was silk ribbon, which was passed between the ends of the bone by means of a long seton needle. J. Oppenheim, Gulliver, and others simply passed it near to the fracture. Great care must be exercised that no important blood-vessel or nerve is transfixed or wounded in the passage of the needle. The seton, according to Dr. Physick, should remain from four to six months; but there is reason to believe that from seven to fourteen days is quite enough for the thread

to accomplish its work. When retained for a greater period, there is danger of the consolidation being defeated in consequence of the profuse suppuration which ensues.

Fig. 605.

Humerus treated by Physick for ununited fracture.

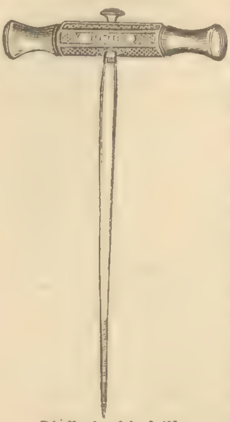
The fatality following the use of the seton in pseudarthrosis of the thigh has been so great that it should receive unqualified condemnation.

In ununited fracture of the humerus it may be adopted with a good prospect of success.

Somme, of Antwerp, has substituted wire for thread with a satisfactory result.

The drill.—Dieffenbach bored a number of holes with a drill (Fig. 606) into the bone, near to the fracture, and then drove into the fragments pegs of ivory. Cases are reported which have been successfully treated by this method, though the operation is not free from danger, death having followed from purulent infection. It is also alleged that the presence of these pegs sometimes produces absorption of the surrounding bone, and even necrosis.

Fig. 606.

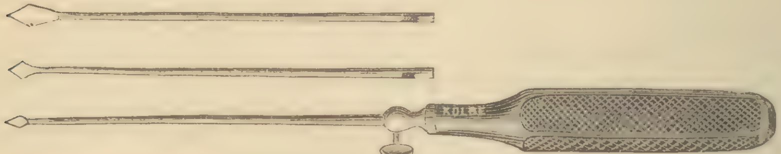


Dieffenbach's drill.

The late Dr. Brainard, of Chicago, employed an awl-shaped drill, well tempered (Fig. 607), and after introducing it through the soft parts, bored through the fragments in different directions, and also through the intermediate structures. His experience led him to believe that three perforations were sufficient. A number of cures have been effected by this method.

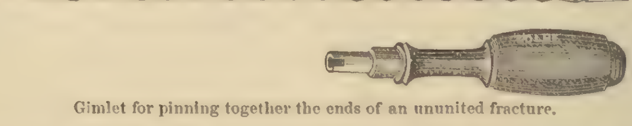
Detmold, of New York, passes a drill, or, more properly, a gimlet (Fig. 608), between the fragments, and then turning the instrument to an oblique position makes it pass through one fragment, across the intermediate substance, and buries it well into the other fragment, thus pinning the two together, the gimlet being allowed to remain until the union becomes well advanced. I believe this plan of pinning together the fragments by a subcutaneous operation was first introduced by Professor Pancoast as early as 1857.

Fig. 607.



Awl-shaped drill.

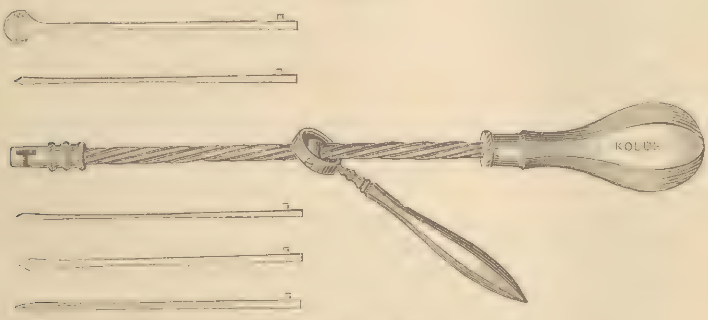
Fig. 608



Gimlet for pinning together the ends of an ununited fracture.

Somewhat analogous to this is the operation of Gaillard, of Louisville, Kentucky. A canula is first conducted down to the bone through an incision made over the fracture. A steel rod, having a gimlet-point at one extremity and a screw thread at the other, is next passed through the canula and bored through the two fragments, thus connecting them together, after which, in order to maintain the instrument in place, a nut is run down over the thread of the rod. This apparatus is allowed to remain until the union is established by callus.

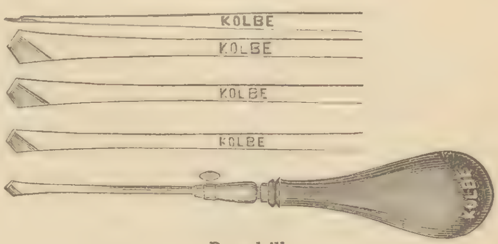
Fig. 609.



Hamilton's bone-drill.

Other drills are in use for making the perforations in the bone, some of which, it is thought, in consequence of the peculiar form of the bit, cut with greater ease to the operator than others. Such are represented in Figs. 609, 610.

Fig. 610.



Bone-drill.

Irritation, with open wound.—Such operations are of very ancient origin. The Arabian physicians knew well the importance of getting rid of the fibrous tissue on the adjacent surfaces of the bone. Avicenna cut down boldly upon the fracture and rasped off the incrustation. The operation, according to his own account, was often fatal. A similar operation was performed, with slight modifications, by Brodie and by Hunter.

In 1760, White, of Manchester, England, introduced the operation of cutting down upon the bone, turning out the ends of the fracture, and sawing off a portion from each, thus getting rid entirely and quickly of the fibrous coverings. This is probably a very old operation. Such resections have been very frequently practiced both in this country and abroad, and with varying results. There are few, however, at the present time who do not regard such a procedure, when applied to large bones like the femur or the tibia, as one of danger to the life of the patient. As an aid to the method by ablation, and in order to maintain accurate contact, wire thread has been introduced through the fragments. This suggestion was made by Horeau as early as 1805. The ends are first removed by the saw, and a hole drilled through each fragment for the passage of the silver wire, by tightening which the parts are firmly secured together. These were the steps of the operation as executed first in this country by Dr. J. Kearney Rodgers.

Professor Bigelow, of Boston, furnishes a list of ten cases successfully treated on the above plan, but with the important addition of preserving the periosteum.

Jordan advises, before resecting the ends of the bone, to detach the periosteum, assuming that when this is omitted and union does not follow, the failure is due to the absence of this membrane over the seat of coaptation. He effects the separation by means of a blunt instrument, and, after excising the callous extremities of the bone, slips one cylinder of the periosteum within the other.

Caustics.—Caustic potash, nitric acid, and even the actual cautery have been applied to the ends of the fragments after their exposure, by Cline, Barton, Hewson, Norris, and others.

Dr. Norris speaks very favorably of this plan of treatment, regarding it in obstinate cases, or in such as have long resisted the ordinary measures resorted to in the management of false joint, as the most powerful means of exciting the requisite irritation for the production of callus in both the bone and its periosteum, and at the same time not causing any very prolonged suppuration, which would tend to defeat rather than to further the osseous consolidation.

In order to apply the caustic properly, the seat of the fracture must be exposed, the dense fibrous incrustation on the ends of the bone thoroughly divided, and the parts dried. The caustic is now applied to the denuded extremities of the fragments, the surrounding parts being at the same time protected from contact with the alkali or the acid employed. The wound should be packed with lint, and the parts placed in a state of entire repose. The caustic potash is considered by Norris to be the best agent for the cauterization.

After all these operations, it is necessary that the limb be put up in an apparatus which will maintain the fragments in a state of perfect rest.

With such an array of operations, the reader may be embarrassed to know where to fix his faith. We very naturally refer to statistics to settle what is certainly, at this date, a very unsettled subject. I am satisfied that the mortality from operations of this nature is far greater than is generally supposed by the profession. I can recall quite a number of cases which I know to have terminated fatally, and which have never been placed on record.

The most valuable paper ever written upon this subject is from the pen of Dr. George Norris, of Philadelphia, and has been referred to by surgeons of almost every nationality: I compile from his recent work, entitled "Contributions to Practical Surgery," the following table of the 150 cases:

No.	Bone.	Cured.	Died.	Not benefited.	Result unknown.
48	Femur	31	6	9	2
33	Leg	32	...	1	...
48	Humerus	31	...	14	3
19	Forearm.	17	...	1	1
2	Jaw	2	...	...	...
150		113	6	25	6

Of 46 cases in which the seton was employed, 36 were cured, 3 were partial cures, in 5 no benefit was experienced, and 2 died. Of these 46 cases, 13 were in the femur, 9 of which were cured; 10 were in the bones of the leg, 10 of which were cured; 16 were in the humerus, with 10 cures; 6 were in the forearm, with 6 cures; and 1 was in the jaw, with 1 cure. The average duration of the false joint in these cases was twelve months and twelve days.

In 38 cases resection was practiced, 24 of which were cured, 1 partially cured, 7 derived no improvement, and 6 died. Of this number, 12 were in the femur, of which 7 were cured; 6 were in the bones of the leg, 5 of which were cured; 12 were in the humerus, with 6 cures; 7 were in the bones of the forearm, with 5 cures and 1 improved; and 1 was in the jaw, with 1 cure. The longest duration of the fracture in the above cases was five years (the femur), and the shortest period ten weeks (the humerus).

Of the 36 patients treated by pressure and rest, 29 were cured, 1 was partially relieved, and 6 received no benefit. Of this group, 13 were in the femur, with 9 cures; 7 in the leg, with 7 cures; 12 in the humerus, with 9 cures; and 4 in the forearm, with 4 cures. The average duration of the fracture in these cases was five months.

In 11 cases the patients were subjected to the treatment by friction, all of whom were cured.

In 8 cases treated by caustic, 6 were successes and 2 were failures.

In 11 cases in which other methods were employed, such as iodine injections and the hot iron, 7 were cured, 1 remained unimproved, 2 died, and in 1 no result was given.

The age was ascertained in 112 cases, and was as follows: 14 were between ten and twenty years, 53 between twenty and thirty, 21 between thirty and forty, and 24 over forty.

In examining the cases tabulated by Dr. Norris, I find 25 in which the duration of the fracture varied from four to fourteen weeks, and which can scarcely be accepted as true cases of non-union, as it is highly probable that a large proportion of these were only instances of delayed union and would eventually have consolidated.

The remarkable success of friction as compared with the other plans of treatment, namely, 11 cases and 11 cures, as the author remarks, is more apparent than real, as in 13 of the cases treated successfully by the seton and by resection, friction had been previously tried and failed.

If the antiseptic plan of treating wounds should be found, on a larger experience, to merit the confidence of the profession, the operation of resection will have been disarmed, in a great measure, of its danger, and might be practiced in many cases with excellent results.

The conclusions deduced by Dr. Norris from the analysis of the 150 cases collected as a basis of comparison between the relative merits of the seton and of resection, are, that the seton is "safer, speedier, and more successful than resection or caustic; that it is least successful in the femur and the humerus;" and that the danger from either plan increases with the size of the limb.

The following tables of ununited fracture have been compiled for me by Dr. Frank Muhlenberg from various medical periodicals, and not only illustrate every variety of treatment for the cure of non-union, but also give much interesting detail in connection with this subject.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
1	Inferior max.	Not stated.	Gunshot.	Not stated.	M.	32	41 months.	Scraping both ends.
2	"	"	Not stated.	"	M.	Ad.	4 months.	Scraping ends, drilling them, and wiring together.
3	"	"	"	"	M.	29	5 weeks.	Perfect rest, splints, and tonic treatment.
4	"	"	"	"	M.	50	5 months.	Drilling ends through mucous surface.
5	"	Near symphysis.	"	Oblique.	M.	Ad.	5 weeks.	Drilling both ends, and op. repeated three times, at intervals of few days.
6	"	Near symphysis.	"	Not stated.	M.	Ad.	8 weeks.	Perfectly fitting interdental splint.
7	"	Line 2d incisors.	Double, compound.	"	M.	27	5 weeks.	Wire around teeth, on both sides.
8	"	Line of canines.	Double.	Oblique.	M.	57	20 months.	Drilling both ends, and uniting by silver wire.
9	"	Between canines.	Comminuted.	Not stated.	M.	Ad.	4 months.	Rubber interdental splint screwed into teeth on each side.
10	"	Bet. bicuspid and canines.	Double.	Vertical.	M.	28	3 months.	Drilling both ends on each side jaw, and drill left in.
11	"	Bet. bicuspid and molar.	Jaw immovable.	Not stated.	M.	13	3 months.	Drilling both ends and uniting by two copper nails, driven in.
12	"	Body.	Not stated.	"	M.	26	5 weeks.	Wire around bicuspid tooth, fastened to external pad.
13	"	First molar.	"	Transverse.	M.	30	4 weeks.	Hard rubber interdental splint.
14	"	Front of masseter.	Compound.	Oblique.	M.	50	9 weeks.	Drilling the ends, and uniting by silver wire.
15	"	Front of masseter.	Double.	Not stated.	M.	24	Some wks.	Wiring teeth together, and interdental splint.
16	"	Angle.	Not stated.	"	M.	35	Months.	Scraping ends with strong needle; pasteboard splints.
17	Clavicle.	Not stated.	"	"	M.	Ad.	Many years.	Seton.
18	Scapula.	Acromion process.	"	"	M.	Ad.	Not stated.	Several needles between ends of bone; firm bandaging.
19	Humerus.	Not stated.	"	"	M.	70	6 months.	Splints, firm pressure, and tonics.
20	"	"	"	"	M.	70	7 months.	Seton, between ends of bone.
21	"	"	"	"	M.	Ad.	12 months.	Dissecting up periosteum, resection ends, drilling, and union by wire.
22	"	"	"	"	F.	50	Weeks.	Several needles, daily stirred around between ends; galvanism.
23	"	"	"	"	M.	40	12 weeks.	Resection, both ends, and uniting by platinum wire.
24	"	"	"	"	M.	40	14 weeks.	Resection, both ends, with bone-pliers.
25	"	"	"	Oblique.	M.	37	Some wks.	Seton, between ends.
26	"	"	"	Not stated.	M.	Ad.	5 months.	Seton, between ends, and splints.
27	"	"	"	Oblique.	M.	21	6 weeks.	Forcible friction of ends together, daily, for four days.
28	"	"	"	Not stated.	M.	Ad.	Weeks.	Seton, between ends.
29	"	"	"	"	M.	Ad.	12 months.	Drilling ends, and operation repeated, at intervals of several days.
30	"	"	"	"	M.	16	9 months.	Scraping ends with strong needle; starch bandage.
31	"	"	"	"	M.	49	12 weeks.	Trocar and canula pushed between ends of bone, and left in.
32	"	"	"	"	M.	51	15 months.	Seton, between ends of bone.
33	"	"	Compound.	"	M.	23	10 months.	Puncturing with needle, obliquely, and breaking up interposed substance.
34	"	"	Not stated.	"	F.	39	2 months.	Dextrine bandage; pasteboard splints.
35	"	"	"	"	F.	Ad.	2½ years.	" " " "
36	"	"	"	"	M.	47	Months.	Resection of both ends of bone.
37	"	"	"	"	M.	47	2½ years.	Resection of both ends, and uniting them by silver wire.
38	"	"	"	"	M.	24	3 months.	Rest and splints.
39	"	"	"	"	M.	30	8 months.	Acupuncture, with electricity.
40	"	"	"	"	M.	24	4 months.	Resection, and union by silver wire.
41	"	"	"	"	F.	Cd.	4 months.	Resection, three-fourths of an inch from one end; scarification of the other; union by silver wire.
42	"	"	"	Transverse.	M.	6	15 weeks.	Tincture iodine locally.
43	"	"	Compound, comminuted.	Not stated.	M.	42	3 years.	Two pegs were driven in, after Dieffenbach's method.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
1	Cut down.	Not stated.	....	14 weeks.	Cured.	C. Heath.	Not stated.	London Med. Times and Gaz., vol. i., 1863.
2	"	"	4 months.	4 months.	"	E. S. Cooper.	"	Philada. Med. and Surg. Reporter, June 14, 1862.
3	....	"	....	11 weeks.	"	G. Buck.	"	Trans. New York Acad. Med., vol. i., 1847–57.
4	Subcutan.	"	....	7 weeks.	"	D. Hayes Agnew.	"	Records Surg. Wards in Pennsylvania Hospital.
5	"	"	....	6 weeks.	"	D. Brainard.	"	Trans. Amer. Med. Assoc., vol. vii., 1854.
6	....	"Union progressing."	....	9 weeks.	Relieved.	B. H. Riggs.	"	Southern Jour. Med. Sci., May, 1867.
7	....	Not stated.	4 months.	Not stated	Cured.	A. Watson.	"	Edinburgh Med. and Surg. Jour., vol. lxi., 1844.
8	Cut down.	"	9 weeks.	4 months.	"	E. S. Cooper.	"	New York Amer. Med. Times, Aug. 17, 1861.
9	....	"	....	3 months.	"	T. B. Gunning.	"	New York Med. Jour., vol. iv., 1866.
10	Cut down.	"	15 days.	6 weeks.	"	E. R. Bickersteth.	"	London Medico-Chirurg. Trans., vol. xxxi., 1848.
11	"	Lower nail rem'd in.	Upper nail 22 days.	5 weeks.	"	"	"	London Medico-Chirurg. Trans., vol. xlviii., 1864.
12	....	Not stated.	....	5 weeks.	"	Wormald.	"	London Med. Times and Gaz., vol. i., 1863.
13	....	"	....	3 weeks.	"	D. R. Silver.	"	Philada. Med. and Surg. Reporter, April 26, 1873.
14	Cut down.	"	4 weeks.	6½ wks.	"	R. A. Kinlock.	"	Amer. Journal Med. Sci., July, 1859.
15	"	Pyæmia.	....	13 days.	Died.	G. Darby.	"	Boston Medical and Surg. Jour., Aug. 19, 1869.
16	Subcutan.	Virulent variola.	....	2 weeks.	"	J. Miller.	"	Edinburgh Monthly Jour. Med. Sci., vol. ii., 1847.
17	Not stated.	Not stated.	Several weeks.	Some wks	Cured.	B. Brodie.	"	Brodie's Lectures on Pathology and Surgery.
18	Subcutan.	Supposed ossification.	Not stated	"	Relieved.	W. J. Moore.	"	British Med. Jour., July, 1859.
19	....	Not stated.	....	4 weeks.	Failed.	B. Vallance.	"	Trans. Provin. Med. and Surg. Assoc., 1850.
20	Subcutan.	Free suppuration.	14 days.	Not stated	Cured.	"	Pressure.	Trans. Provin. Med. and Surg. Assoc., 1850.
21	Cut down.	Not stated.	Not stated	"	"	M. Demarquay.	Not stated.	L'Union Médicale, 1867.
22	Subcutan.	"	....	6 weeks.	"	W. J. Moore.	"	British Med. Jour., July, 1859.
23	Cut down.	Pyæmia.	Not stated	5 weeks.	Died.	Busk.	"	London Med. Times, vol. xiii., N. S., 1856.
24	....	Not stated.	....	8 weeks.	Cured.	J. Spence.	"	London Med. Times and Gaz., vol. i., 1872.
25	Subcutan.	"	2 months.	2½ mos.	"	M. Baroni.	"	Bullettino delle Scienze Mediche, Jan. 1842.
26	"	Abscess.	3 weeks.	11 weeks.	"	T. H. Babington.	"	Dublin Jour. Med. Sci., vol. xli., 1866.
27	....	Not stated.	....	6 weeks.	"	M. Biagnini.	"	Gazette des Hôpitaux, Nov. 25, 1847.
28	Subcutan.	"Result, all that could be expected."	2 weeks.	Some wks	Relieved.	D. Prince.	"	Chicago Med. Examiner, Dec. 1863.
29	"	Not stated.	....	8 weeks.	Cured.	J. C. Stone.	Resection.	Chicago Med. Jour., May, 1861.
30	"	Not stated.	....	2 months.	"	G. Y. Heath.	Not stated.	London Lancet, Sept. 1855.
31	"	"Ossification going on."	4 days.	Not stated	Relieved.	J. Adams.	"	London Med. Times, vol. ii., N. S., 1851.
32	"	Free suppuration.	10 days.	"	"	"	"	London Med. Times, vol. ii., N. S., 1851.
33	"	Not stated.	....	5 weeks.	"	J. Miller.	"	Edinburgh Monthly Jour. Med. Sci., June, 1848.
34	....	"	....	Not stated	Cured.	A. L. M. Velpeau.	"	Velpeau's Surgery.
35	....	"	....	9 weeks.	"	"	"	Velpeau's Surgery.
36	Cut down.	"	....	6 months.	Failed.	"	"	Gazette des Hôpitaux, Jan. 13, 1846.
37	"	"	....	4 months.	"	"	Seton, friction.	Gazette des Hôpitaux, Jan. 13, 1846.
38	....	"	....	21 weeks.	Cured.	J. Syme.	Not stated.	Observations in Clinical Surgery (J. Syme).
39	Subcutan.	"	....	Not stated	"	N. Y. Hospitals.	Drilling, friction.	Malgaigne on Fracture (Packard), p. 261, 1859.
40	Cut down.	"	5 weeks.	"	Relieved.	"	Not stated.	Malgaigne on Fracture (Packard), p. 255.
41	"	"	13 days.	"	"	"	"	Malgaigne on Fracture (Packard), p. 255.
42	....	"	....	3 weeks.	Cured.	J. Paul.	"	Conservative Chir., p. 291.
43	Subcutan.	Abscess.	4 days.	5 weeks.	"	"	"	Günsburg's Zeitschrift Klin. Med., i. p. 142.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
44	Humerus.	Not stated.	Not stated.	Not stated.	M.	34	12 months.	Two pegs were driven in, after Dieffenbach's method.
45	"	"	Gunshot.	"	M.	31	Not stated.	Three pegs were driven in, after Dieffenbach's method.
46	"	"	Not stated.	"	M.	Ad.	Long time.	H. H. Smith's apparatus,—retaining fracture nearly immovable, but allowing motion at elbow-joint.
47	"	"	Compound.	"	M.	31	5 months.	Seton, between ends.
48	"	"	Comminuted.	"	M.	31	4½ months.	" " "
49	"	"	Not stated.	"	M.	Ad.	Not stated.	Irritating false joint, with a spatula.
50	"	"	"	"	M.	Ad.	12 months.	Resection.
51	"	"	"	"	M.	Ad.	Not stated.	"
52	"	"	"	"	M.	Ad.	"	"
53	"	"	"	"	M.	Ad.	"	"
54	"	"	"	"	M.	Ad.	"	"
55	"	"	"	"	M.	Ad.	"	"
56	"	"	"	"	F.	Ad.	10 months.	"
57	"	"	"	"	M.	Ad.	18 months.	"
58	"	"	"	"	M.	Ad.	3 months.	Resection of upper end.
59	"	"	"	"	M.	Ad.	Not stated.	Seton.
60	"	"	"	"	M.	Ad.	"	"
61	"	"	"	"	M.	Ad.	"	"
62	"	"	"	"	M.	Ad.	"	"
63	"	"	"	"	M.	Ad.	Several months.	Resection of both ends.
64	"	"	"	"	M.	Ad.	Not stated.	Resection, drilling, and uniting ends, by thread.
65	"	"	"	"	F.	7	16 months.	Stirring up the interposed mass; two steel screws introduced through end.
66	"	"	"	"	M.	Ad.	Not stated.	Resection of both ends.
67	"	"	"	"	M.	37	"	Resection.
68	"	"	"	"	F.	31	21 months.	"
69	"	"	"	"	M.	36	14 months.	Resection of both ends, and steel screw placed in end.
70	"	"	"	"	M.	36	14 weeks.	Scarification of both ends; starch bandage.
71	"	Surgical neck.	"	"	M.	50	6 months.	H. H. Smith's apparatus,—retaining fracture nearly immovable, but allowing motion at elbow.
72	"	"	"	Oblique.	M.	56	3 months.	Drilling both ends; bandage of plaster Paris.
73	"	"	"	"	M.	56	6½ months.	Drilling both ends; uniting them by iron wire.
74	"	"	"	Not stated.	M.	28	35 months.	Resection of lower fragment; steel screw placed in each end.
75	"	Upper third.	"	"	F.	28	3 months.	Firm pressure, and iron splint.
76	"	"	"	"	F.	28	4 months.	Compression to utmost, and splints.
77	"	"	"	"	F.	28	6 months.	Forcible friction of ends together.
78	"	"	"	"	F.	28	28 weeks.	Seton between ends, and firm support.
79	"	"	"	"	F.	28	9 months.	Plaster Paris dressing, and recumbent position.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
44	Subcutan.	Consider'ble inflam'tion.	5 days.	5 weeks.	Cured.	J. Paul.	Not stated.	Günsburg's Zeitschr. Klin. Med. i., Beob. 97, p. 301.
45	"	Moderate inflam'tion.	6 days.	Not stated	Failed.	"	"	Günsburg's Zeitschr. Klin. Med. i., Beob. 19, p. 158.
46	....	Not stated.	....	"	Relieved.	C. W. Ashby.	"	American Jour. Med. Sci., Jan. 1855.
47	Subcutan.	"	8 days.	7 weeks.	Cured.	Jobert (de Lamballe).	"	Gazette des Hôpitaux, 1850, p. 434.
48	"	Amputat'n.	Not stated	Not stated	Failed.	Jobert (de Lamballe).	"	Gazette des Hôpitaux, 1851, p. 14.
49	Cut down.	Not stated.	....	"	Cured.	J. Hunter.	"	London Med. Gazette, vol. xiii., 1834, p. 58.
50	"	"	....	"	Failed.	J. Bell.	"	Surgery (Allan's), vol. ii. p. 88, 1821.
51	"	"	....	"	Cured.	"	"	Principles Surgery, vol. ii. p. 20. (London.)
52	"	"	....	"	"	Dupont.	"	Archives Gén. de Méd., t. ii. p. 628, 1823.
53	"	"	....	18 mos.	Failed.	A. Hewson.	"	Amesbury on Fractures, p. 160.
54	"	"	....	Many months.	"	"	"	Amesbury on Fractures, p. 160.
55	"	"	....	Not stated	"	J. H. James.	"	Trans. Prov. Med. & Surg. Assoc., vol. viii., 1840.
56	"	"	....	8 months.	"	Macmurdo.	Seton twice.	Chelius's Surgery, vol. i. p. 588 (1847).
57	"	"	....	2 months.	Cured.	Chelius.	Not stated.	Chelius's Surgery, vol. i. p. 439 (1843).
58	"	"	....	Not stated	Failed.	Moreau.	"	L'Emploi de la Résect. des Os, p. 72, 1816.
59	Subcutan.	"	Not stated	"	Relieved.	Hornier.	"	Velpeau's Med. Operat., t. i. p. 532.
60	"	"	"	"	Failed.	"	"	Velpeau's Med. Operat., t. i. p. 532.
61	"	"	"	"	Relieved.	Béclard.	"	Vallet, Consid. sur Non-Consold. Fract. des Os longs, 1817.
62	"	"	"	"	Failed.	Not stated.	"	Sabbatier Med. Operat., t. iv. p. 462, 1824. (From Gurlt's Surgery.)
63	Cut down.	"	....	3 months.	Cured.	R. L. Williams.	"	Provin. Med. and Surg. Jour., p. 548, 1851.
64	"	"	20 days.	Not stated	Failed.	Flaubert.	"	Malgaigne's Surg. (Fractures), p. 316.
65	Subcutan.	"Cure going on."	5 weeks.	7 months.	Relieved.	B. Langenbeck.	"	Deutsche Klinik, p. 264, 1854.
66	Cut down.	Not stated.	....	Not stated	Cured.	"	"	Med. Chirg. Zeitung, Bd. ii p. 350, 1820.
67	"	"	....	5½ mos.	Failed.	Von Walther.	Tincture of iodine.	Weber, in Chirg. Erfahr. u. Unters., 1859. (From Gurlt's Surgery.)
68	"	"	....	33 days.	Cured.	Fawdington.	Not stated.	J. C. Neild, Diss. d. pseud. quæ os frac. seq., p. 16, 1839.
69	"	"	4 days.	3 months.	Failed.	W. Busch.	"	Weber, in Chirg. Erfahr., 1859. (Gurlt's Surgery.)
70	"	"	....	11¼ mos.	Cured.	Wutzer.	"	Weber, in Chirg. Erfahr., 1859. (Gurlt's Surgery.)
71	....	Union progressing.	....	Not stated	Relieved.	G. Dock.	"	American Jour. Med. Sci., Jan. 1855.
72	Subcutan.	Not stated.	....	"	Failed.	Dr. P——.	"	St. Louis Med. and Surg. Jour., Nov. 1869.
73	"	"	3 months.	3 months.	Cured.	J. T. Hodgen.	Drilling and met. spikes.	St. Louis Med. and Surg. Jour., Nov. 1869.
74	Cut down.	"	22 days.	Not stated	Failed.	B. Langenbeck.	Not stated.	B. Langenbeck's Klinik. (Gurlt's Surgery.)
75	....	"	....	4 weeks.	"	Not stated.	"	Guy's Hospital Reports, vol. ii., 1837.
76	....	"	....	2 months.	"	"	Immovable splint.	Guy's Hospital Reports, vol. ii., 1837.
77	....	"	....	2 weeks.	"	B. Cooper.	Immovable splint and pressure.	Guy's Hospital Reports, vol. ii., 1837.
78	Subcutan.	Slight inflammation.	Not stated	11½ wks.	"	"	Immovable splint, pressure, and friction.	Guy's Hospital Reports, vol. ii., 1837.
79	....	Not stated.	....	4 weeks.	"	"	Immovable splint, pressure, friction, and seton.	Guy's Hospital Reports, vol. ii., 1837.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
80	Humerus.	Upper third.	Not stated.	Not stated.	F.	28	$10\frac{1}{2}$ mos.	Ptyalism, and leathern girth.
81	"	"	"	"	M.	37	7 months.	Resection of both ends, by strong bone forceps.
82	"	"	"	"	M.	Ad.	Some mos.	Resection of both ends.
83	"	"	"	Oblique.	M.	30	4 months.	Drilling both ends, and repeating operation, in ten days.
84	"	"	Simple.	"	M.	59	5 months.	Drilling, with Pancoast's screw and gimlet, and this left in.
85	"	"	Not stated.	Not stated.	Cd.	11	6 months.	Immovable dressing, by use of starch bandage.
86	"	"	"	"	Cd.	11	8 months.	Firm pressure by "Grande Cuirasse."
87	"	Junc. of upper and middle thirds.	Comminuted.	"	M.	41	11 months.	Periosteum dissected up for an inch, ends resected, drilled, and wired together.
88	"	Junc. of upper and middle thirds.	Compound.	"	M.	40	3 months.	Seton.
89	"	Junc. of upper and middle thirds.	Not stated.	"	M.	24	12 months.	Seton, and starch bandage.
90	"	Junc. of upper and middle thirds.	"	"	M.	Ad.	4 years.	" " "
91	"	Middle third.	"	"	M.	35	7 weeks.	Drilling upper end of lower fragment; gutta-percha splints.
92	"	"	Comminuted.	"	M.	24	8 months.	Resection of both ends, drilling them, and uniting them by gold wire.
93	"	"	Simple.	"	M.	47	4 months.	Hydrarg. chlor. mit. for 10 days, until ptyalism was produced.
94	"	"	"	"	M.	47	$5\frac{1}{2}$ months.	Blisters.
95	"	"	"	"	M.	47	$6\frac{1}{2}$ months.	Seton.
96	"	"	Not stated.	"	M.	20	3 months.	Drilling both ends, and repeating in three weeks.
97	"	"	"	Oblique.	M.	15	10 months.	Scraping ends, and a dossil of lint left in wound.
98	"	"	Comminuted.	Not stated.	M.	31	12 months.	Periosteum reflected for an inch, ends resected, drilled, and wired.
99	"	"	Simple.	"	M.	28	13 weeks.	Drilling each end.
100	"	"	"	"	M.	28	5 months.	Periosteum reflected, ends resected, drilled, and wired by silver-plated copper wire.
101	"	"	Compound, comminuted.	"	M.	18	6 months.	Resection of both ends; drilling; ends united by wire.
102	"	"	Compound, comminuted.	"	M.	20	$2\frac{1}{2}$ years.	Periosteum reflected, and ends resected.
103	"	"	Compound, comminuted.	"	M.	22	$3\frac{1}{2}$ years.	Periosteum reflected, ends resected, drilled, and wired together.
104	"	"	Compound, comminuted.	"	M.	23	5 years.	Periosteum reflected, ends resected, drilled, and wired together.
105	"	Middle.	Not stated.	"	M.	68	7 weeks.	Angular splint; gum and chalk bandage.
106	"	"	"	"	F.	32	7 weeks.	Splints, tonics, and country air.
107	"	"	"	"	M.	29	9 months.	Immovable apparatus.
108	"	"	Compound.	"	F.	22	6 weeks.	Starch bandage.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
80	....	Salivation for 6 days.	....	4 weeks.	Cured.	B. Cooper.	Immovable splint, pressure, friction, and seton.	Guy's Hospital Reports, vol. ii., 1837.
81	Cut down.	Not stated.	....	6 weeks.	"	J. Fife.	Splints.	Provincial Med. Journal, Dec. 16, 1843.
82	"	"	....	Not stated	"	T. Wakley.	Not stated.	Dublin Medical Press, 1858.
83	Subcutan.	"	....	6 weeks.	"	D. Brainard.	"	Chicago Med. Jour., Sept. 1855.
84	"	"Patient had attack of hemiplegia, and callus, which was progressing, degenerated."	45 days.	18 weeks.	Failed.	J. H. Brinton.	"	Per letter to D. Hayes Agnew.
85	....	Not stated.	....	6 weeks.	"	M. Bonnet.	"	Gazette Médicale, Sept. 1839.
86	....	"	....	3 months.	Cured.	"	Starch bandage.	Gazette Médicale, Sept. 1839.
87	Cut down.	Suppuration	5 months.	5 months.	"	H. J. Bigelow.	Resection.	Boston Medical and Surg. Jour., May 16, 1867.
88	Subcutan.	Not stated.	8 days.	3 months.	"	Jobert (de Lamballe).	Not stated.	Gazette des Hôpitaux, p. 409, 1840.
89	"	"	10 days.	8 weeks.	"	Nélaton.	"	Gazette des Hôpitaux, p. 492, 1853.
90	"	"	Not stated	Not stated	"	"	"	Thèse, De la Consold. Fract., 1853, by F. Jolians.
91	Cut down.	"	....	6 weeks.	"	F. H. Hamilton.	"	Buffalo Med. Jour., Aug. 1854.
92	"	"	3 months.	3 months.	"	J. Crosby.	"	North American Med.-Chir. Rev., July, 1858.
93	....	"	....	3 weeks.	Failed.	Not stated.	Resection.	New York Med. Times, Oct. 1851.
94	....	"	....	3 weeks.	"	G. Buck.	Ptyalism.	New York Med. Times, Oct. 1851.
95	Subcutan.	Profuse suppuration.	4 weeks.	4 months.	Cured.	"	Ptyalism, and blisters.	New York Med. Times, Oct. 1851.
96	"	Not stated.	....	6 weeks.	"	R. D. Mussey.	Not stated.	Trans. Amer. Med. Assoc., vol. vii., 1854.
97	Cut down.	"	7 days.	4 weeks.	"	E. Davies.	"	London Lancet, vol. i., Feb. 1859.
98	"	"	8 weeks.	3 months.	"	H. J. Bigelow.	"Various measures."	Boston Medical and Surg. Jour., May 16, 1867.
99	Subcutan.	"	....	7 weeks.	Failed.	Not stated.	Not stated.	Boston Medical and Surg. Jour., May 16, 1867.
100	Cut down.	"Divided musculo-spiral nerve, tied by suture. Motion and sensation, perfectly restored to hand."	....	5 months.	Cured.	H. J. Bigelow.	Drilling.	Boston Medical and Surg. Jour., May 16, 1867.
101	"	Not stated.	2 weeks.	Some wks	Failed.	Not stated.	Not stated.	Boston Medical and Surg. Jour., May 16, 1867.
102	"	"	....	4 months.	"	H. J. Bigelow.	Resection, wiring.	Boston Medical and Surg. Jour., May 16, 1867.
103	"	"Rebroke, partially consoli'ed joint, after 2½ months."	....	3½ mos.	"	"	Resection, wiring.	Boston Medical and Surg. Jour., May 16, 1867.
104	"	"7 inches shortening"	....	3 months.	Cured.	"	Resection, wiring.	Boston Medical and Surg. Jour., May 16, 1867.
105	....	Not stated.	....	45 days.	Died.	J. Nichols.	Not stated.	St. George's Hosp. Reports, vol. iv., 1869.
106	....	"	....	4 weeks.	Cured.	W. B. Page.	"	London Medico-Chirurg. Trans., vol. xxxi., 1848.
107	....	"Union, but not osseous"	....	4 months.	Relieved.	Not stated.	"	London Medico-Chirurg. Trans., vol. li., 1868.
108	....	Not stated.	....	4 months.	Failed.	"	"	Gazette Médicale, June 25, 1842.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
109	Humerus.	Middle.	Compound.	Not stated.	F.	22	6 months.	Seton between ends, and starch bandage.
110	"	"	"	"	F.	22	11 months.	Seton, between ends.
111	"	"	Simple.	"	M.	35	9 weeks.	Scraping ends with knife, and splints.
112	"	"	"	"	M.	35	5 months.	Resection of both ends; starch bandage.
113	"	"	Compound.	"	M.	22	11 months.	Seton, between ends of bone.
114	"	"	"	"	M.	22	15 months.	Forcible friction of ends together, and blistering.
115	"	"	"	"	M.	23	18 months.	Resection of each end.
116	"	"	"	"	M.	24	3 years.	Ends split by strong bone forceps, and partially resected.
117	"	"	"	"	M.	24	38 months.	Periosteum reflected, ends resected, drilled, and wired by silver wire. Also external apparatus, to force ends together.
118	"	"	"	"	M.	26	12 months.	Periosteum reflected, ends resected, drilled, and wired together.
119	"	"	Compound, comminuted.	"	M.	33	2½ years.	Periosteum reflected, ends resected, drilled, and wired together.
120	"	"	Comminuted.	"	F.	Ad.	7 months.	Forcible friction of ends; pasteboard case.
121	"	"	Not stated.	"	M.	31	13 weeks.	Resection of both ends.
122	"	"	"	"	M.	35	3 months.	Plaster Paris bandages, and tonics.
123	"	"	"	"	M.	35	5 months.	Seton of double wire, between bones.
124	"	"	"	"	M.	35	9 months.	Resection of both ends of bone.
125	"	"	"	"	M.	Ad.	Not stated.	" " " "
126	"	"	"	"	M.	54	7 months.	" " " "
127	"	"	"	"	M.	25	20 months.	Resection ends, drilling, and uniting by copper wire.
128	"	"	"	"	M.	20	7 months.	Drilling ends, and five wire pegs driven in.
129	"	"	"	"	M.	37	8 months.	Resection, and union by lead wire.
130	"	"	"	"	M.	33	27 months.	Resection of lower fragment, and two screws placed in.
131	"	"	"	"	M.	36	11½ mos.	Resection of both ends, and screws placed in.
132	"	"	"	"	M.	Ad.	6½ months.	Resection of both ends.
133	"	"	"	"	M.	Ad.	Not stated.	" " "
134	"	"	"	"	M.	55	8 months.	" " "
135	"	"	"	"	M.	16	12 months.	" " "
136	"	"	"	"	M.	33	15 months.	Resection of both ends; divided nerve, united by platinum wire.
137	"	"	Simple.	"	M.	26	4½ months.	Rest, rectangular splint, and starch bandage.
138	"	"	"	"	M.	26	6 months.	Resection of both ends by bone pliers; starch bandage.
139	"	"	Compound.	"	F.	28	4 months.	Drilling both ends, and two ivory pegs driven in.
140	"	"	"	"	F.	28	11 months.	Drilling both ends, and two ivory pegs driven in.
141	"	"	Not stated.	"	M.	31	12 months.	Drilling both ends, and two ivory pegs driven in.
142	"	"	"	"	M.	42	18 months.	Drilling both ends, and two ivory pegs driven in.
143	"	"	"	Oblique.	M.	24	6 weeks.	Drilling both ends, and repeated in fourteen days.
144	"	"	"	"	M.	24	9 weeks.	Seton.
145	"	"	"	"	M.	24	3 months.	Resection both ends of bone.
146	"	"	Compound, comminuted.	Not stated.	M.	29	8 months.	Drilling both ends, and repeated three times, every ten days.
147	"	"	Simple.	"	M.	Ad.	3 months.	Drilling ends, and repeated four times, every fourteen days.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
109	Subcutan.	Not stated.	8 days.	4 months.	Failed.	M. Roux.	Starch bandage.	Gazette Médicale, June 25, 1842.
110	"	"	15 days.	7 months.	Cured.	M. Maisonneuve.	Starch bandage and seton.	Gazette Médicale, June 25, 1842.
111	"	"	....	5 weeks.	Failed.	Not stated.	Not stated.	London Lancet, June, 1866.
112	Cut down.	"	....	4 months.	Cured.	G. Buchanan.	Scraping.	London Lancet, June, 1866.
113	Subcutan.	"	4½ mos.	4½ mos.	Failed.	Not stated.	Not stated.	Boston Medical and Surg. Jour., May 16, 1867.
114	....	"	....	11 weeks.	"	"	Seton.	Boston Medical and Surg. Jour., May 16, 1867.
115	Cut down.	"	....	6 months.	"	"	Seton and friction.	Boston Medical and Surg. Jour., May 16, 1867.
116	"	"	....	4 weeks.	"	"	Seton, friction, and resection.	Boston Medical and Surg. Jour., May 16, 1867.
117	"	"	4 months.	5 months.	Cured.	H. J. Bigelow.	Seton, friction. resection.	Boston Med. and Surg. Jour., May 16, 1867.
118	"	Suppuration	4½ mos.	6 months.	"	"	Not stated.	Boston Med. and Surg. Jour., May 16, 1867.
119	"	Abscess.	4 months.	4 months.	"	"	"	Boston Med. and Surg. Jour., May 16, 1867.
120	....	Not stated.	....	Some months.	Failed.	E. Warren.	"	Boston Med. and Surg. Jour., Aug. 18, 1859.
121	Cut down.	Dysentery.	....	5 weeks.	Died.	Not stated.	"	Reports Gen. Hosp. Vienna, 1857. (Gurlt's Surgery.)
122	....	Not stated.	....	6½ wks.	Failed.	W. Ferguson.	"	London Lancet, vol. ii., 1860.
123	Subcutan.	Severe inflammation.	Not stated	4 months.	"	"	Immovable dressing.	London Lancet, vol. ii., 1860.
124	Cut down.	Not stated.	....	2 months.	Cured.	"	Immovable dressing, and seton.	London Lancet, vol. ii., 1860.
125	"	"	....	Not stated	Failed.	Steinheim.	....	Med. Zeitung Vereins. f. Heilk. in Pract., 1834, p. 210.
126	"	"	....	5 weeks.	"	J. Hamilton.	....	Dublin Quart. Jour. Med. Sci., vol. xxvi., 1844.
127	"	"	....	4 months.	Cured.	S. A. Cusack.	Ivory pegs.	Dublin Hospital Gazette, vol. iv., 1857.
128	"	Erysipelas.	5 months.	5 months.	"	J. Erichsen.	Starch bandage.	British Medical Journal, Nov. 1859.
129	"	....	7 days.	35 days.	"	B. Langenbeck.	Not stated.	B. Langenbeck's Klinik. (Gurlt's Surgery.)
130	"	Violent fever.	8 days.	8 weeks.	Failed.	"	Ivory pegs.	B. Langenbeck's Klinik. (Gurlt's Surgery.)
131	"	"Probably cured."	4 weeks.	10 weeks.	Relieved.	"	Not stated.	B. Langenbeck's Klinik. (Gurlt's Surgery.)
132	"	Not stated.	....	3 weeks.	Cured.	C. J. Langenbeck.	"	Neue Bibliothek f. d. Chirg., Bd. i., 1815, p. 94. (From Gurlt's Surgery.)
133	"	"	....	Not stated	"	Langenbeck.	"	Med. Chirurg. Zeitung, Bd. ii. p. 350, 1820.
134	"	"	....	"	"	Jos. Jordan.	Ivory pegs.	London Med. Times and Gaz., N. S., vol. viii., 1854.
135	"	"	....	10 weeks.	"	H. Hill.	Not stated.	British-American Jour. Med. and Phys. Sci., 1849.
136	"	"	....	4 weeks.	"	F. Esmarch.	"	Deutsche Klinik, p. 236, 1858.
137	....	"	....	6 weeks.	Failed.	J. Spence.	"	Edinburgh Med. Jour., July–Dec. 1866.
138	Cut down.	"	....	Some wks.	Cured.	"	Immovable dressing.	Edinburgh Med. Jour., July–Dec. 1866.
139	Subcutan.	"	20 days.	4 months.	Failed.	J. Birkett.	Not stated.	London Lancet, vol. i., May 25, 1867.
140	"	"	....	9 months.	"	"	Drilling and pegs.	London Lancet, vol. i., May 25, 1867.
141	"	Abscess.	13 days.	12 weeks.	Cured.	Dieffenbach.	Not stated.	Casper's Wochenschrift, p. 733, 1846.
142	"	"	4 days.	Not stated	"	"	Seton, etc.	Casper's Wochenschrift, p. 733, 1846.
143	"	Not stated.	....	3 weeks.	Failed.	M. Gunn.	Not stated.	Detroit Med. Independent, Feb. 1857.
144	"	"	16 days.	16 days.	"	"	Drilling.	Detroit Med. Independent, Feb. 1857.
145	Cut down.	"	....	7 weeks.	"	"	Drilling and seton.	Detroit Med. Independent, Feb. 1857.
146	Subcutan.	"Left hospital."	....	8 weeks.	Relieved.	D. Brainard.	Not stated.	Chicago Medical Journal, Sept. 1858.
147	"	Not stated.	....	5 months.	Failed.	"	"	Chicago Medical Journal, Sept. 1858.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
148	Humerus.	Middle.	Not stated.	Not stated.	M.	Ad.	8½ months.	Seton between ends, and splints.
149	"	"	"	"	M.	Ad.	14½ months.	Resection of both ends, and starch bandage.
150	"	"	"	"	M.	30	3½ months.	Forcible friction of ends, daily, for a week, and then, every other day, for another week.
151	"	"	"	"	F.	Ad.	Not stated.	Seton, between ends of bone.
152	"	"	"	"	M.	30	10 months.	Resection of both ends.
153	"	"	"	"	F.	27	4 months.	Forcible friction of ends together, repeated in four weeks; starch bandage.
154	"	"	"	"	F.	27	5½ months.	Seton, between ends; starch bandage.
155	"	"	"	"	M.	12	8 months.	Seton, between ends of bone.
156	"	"	"	"	M.	13	15 months.	" " " "
157	"	"	"	"	M.	13	18 months.	Resection of ends; drilling, and wiring them together.
158	"	"	"	"	M.	Ad.	Many mos.	Seton, between ends.
159	"	"	"	Oblique.	M.	45	3 months.	Seton of horse-hair.
160	"	"	"	Not stated.	M.	35	2 years.	Seton, between ends; tin splint, afterwards gutta-percha splint.
161	"	"	Simple, comminuted.	"	F.	33	6 weeks.	Forcible friction, and longitudinal pressure.
162	"	"	"	"	F.	33	17 weeks.	Friction, and starch bandage.
163	"	"	Not stated.	"	M.	39	4 years.	Resection of ends; drilling, and wiring them together.
164	"	"	"	"	F.	Ad.	4 months.	Crawford's adjuster for fractured clavicle.
165	"	"	"	"	M.	25	Some mos.	Overlapped ends transfixed by gimlet, which was left in.
166	"	"	"	Oblique.	F.	25	4 months.	Drilling both ends, and repeating operation in twelve days.
167	"	"	"	Not stated.	M.	39	8 months.	Resection of both ends.
168	"	"	Compound.	"	M.	61	8 months.	" "
169	"	"	Not stated.	"	M.	40	12 months.	Resection of both ends; starch bandage.
170	"	"	Compound.	"	M.	38	5 months.	Rest; starch bandage; pasteboard splints.
171	"	"	Not stated.	Oblique.	M.	55	6 months.	Silk seton, between ends of bone.
172	"	"	"	Not stated.	M.	5	12 months.	Chiseling off ends of each fragment.
173	"	"	....	....	M.	40	8 weeks.	Forcible friction of ends together.
174	"	"	....	....	M.	40	3½ months.	Immovable dressing of plaster Paris.
175	"	"	Not stated.	Not stated.	M.	40	8 months.	Drilling ends of bone, and wiring them together.
176	"	Junction of middle and lower thirds.	"	"	M.	50	6 years.	Resecting the ends, and loosening the periosteum.
177	"	"	"	"	F.	19	6 months.	Resecting the ends, and gutta-percha splint.
178	"	"	"	"	M.	Ad.	12 months.	Seton.
179	"	"	"	"	M.	28	11 months.	Steel screw, bored in end, for three-quarters of an inch, and left in.
180	"	"	"	"	M.	44	12 months.	Splints.
181	"	"	Overlapped.	"	M.	44	14 months.	Drilling together, overlapped ends, by two drills, which were left in.
182	"	"	Not stated.	"	M.	9	27 weeks.	Resection of ends; drilling, and uniting them by platinum wire.
183	"	"	"	"	M.	21	3 months.	Tonics, and firm pressure by pads.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
148	Subcutan.	Severe inflammation.	Not stated	4 months.	Failed.	D. Brainard.	Drilling.	Chicago Medical Journal, Sept. 1858.
149	Cut down.	Very severe local and general symptoms.	....	3 months.	"	"	Drilling, and seton.	Chicago Medical Journal, Sept. 1858.
150	....	Not stated.	....	2 months.	Cured.	T. S. Kirkbride.	Not stated.	Amer. Jour. Med. Sciences, vol. xv., 1835.
151	Subcutan.	"	3 weeks.	Not stated	Failed.	Physick.	"	Gibson's Surgery, p. 335, 1841.
152	Cut down.	"	....	18 mos.	"	C. J. Beck.	"	(Gurlt's Surg.) De caus. et struct. pseud., p. 37, 1821, by Ignatius Schwoerer.
153	....	"	....	6 weeks.	"	D. W. Crompton.	"	Lond. Med Gazette, Nov. 8, 1850.
154	Subcutan.	"	6 days.	11 mos.	"	"	Friction, starch bandage.	Lond. Med. Gazette, Nov. 8, 1850.
155	"	"	6 months.	6 months.	"	V. Mott.	Not stated.	Transac. N. Y. Academy Med., vol. i., 1847–57.
156	"	"	Not stated	Not stated	"	"	Seton.	Transac. N. Y Academy Med , vol. i., 1847–57.
157	Cut down.	"	Few days.	Few wks.	Cured.	J. K. Rodgers.	Seton twice.	Transac. N. Y. Academy Med., vol. i., 1847–57.
158	Subcutan.	"	5 days.	Few days.	Died.	Hornier.	Not stated.	Larrey's Clinique Chirur., t. i., 1830.
159	"	"	6 weeks.	5 months.	Cured.	Cairoli.	"	Rust's Magazine, Bd. 27, p. 270, 1828.
160	"	"	9 days.	14 weeks.	"	Hecker.	"	From (Gurlt's Surgery) Vierteljahresschrift f. d. Heilk. Pr., Bd. 44, p. 180, 1854.
161	....	"	....	9 weeks.	Failed.	W. Marsden.	"	Brit.-Amer. Jour. Med. and Phys. Science, Oct. 1845.
162	....	"	....	5 weeks.	Cured.	"	Friction, and pressure.	Brit.-Amer. Jour. Med and Phys. Science, Oct. 1845.
163	Cut down.	"	6 weeks.	8 weeks.	"	E. S. Cooper.	Not stated.	Amer. Med. Times, 1861.
164	....	"	....	2½ mos.	"	D. P. Smith.	"	Amer. Med. Times, Aug. 4, 1860.
165	Subcutan.	"	Not stated	Not stated	"	Parker.	Drilling, seton.	N. Y. Amer. Med. Times, Jan. 1861.
166	"	"	....	4 weeks.	"	J. Crosby.	Not stated.	Transac. New Hampshire Med. Society, p. 28, 1857.
167	Cut down.	"	....	4 months.	"	Wutzer.	"	Stachelhausen, Diss. Pseudarth., 1838 (Gurlt's Sur.)
168	"	"	....	4 months.	"	"	Friction.	Stachelhausen, Diss. Pseudarth., 1838 (Gurlt's Sur.)
169	"	"	....	13 weeks.	"	J. Syme.	Not stated.	Syme's Observations in Clinical Surgery.
170	....	"	....	22 weeks.	"	"	Friction, starch bandage.	Syme's Observations in Clinical Surgery.
171	Cut down.	"	30 days.	6 weeks.	"	J. M. Warren.	Not stated.	Warren's Surgical Observations and Cases.
172	Subcutan.	"	....	40 days.	"	J. H. Brinton.	"	Per letter to D. Hayes Agnew.
173	....	"	....	6 weeks	Failed.	Lake.	"	Lond. Med. Times and Gazette, vol. i., May 9, 1874.
174	....	"	....	Some wks	"	"	Friction.	Lond. Med. Times and Gazette, vol. i., May 9, 1874.
175	Cut down.	"	6 weeks.	3 months.	Cured.	"	Friction, starch bandage.	Lond. Med. Times and Gazette, vol. i., May 9, 1874.
176	"	"	....	2 months.	Failed.	J. Jordan.	Not stated.	Lond. Med. Times and Gazette, N. S., vol. viii., 1854.
177	....	"	....	5½ mos.	Cured.	R. Wilms.	"	Deutsche Klinik, p. 360, 1854.
178	Subcutan.	"Cure expected."	7 days.	Not stated	Not stated	Curling.	"	Lond. Lancet, vol. ii., 1858.
179	"	Not stated.	12 days.	13 weeks.	"	B. Langenbeck.	"	Deutsche Klinik, p. 314, 1855.
180	....	"	....	3 months.	Failed.	Fletcher.	"	Lond. Medico-Chir. Trans., vol. xlvii., 1864.
181	Subcutan.	"	One, 6 days; other, 13 days.	5 months.	Cured.	"	Splints.	Lond. Medico-Chir. Trans., vol. xlvii., 1864.
182	Cut down.	"	13 days.	4 weeks.	"	J. Russell.	Not stated.	Lond. Assoc. Med. Journ., June, 1854.
183	....	"	....	8 weeks.	Failed.	J. Spence.	"	Edinburgh Med. Jour., vol. i., 1855–56.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
184	Humerus.	Junction of middle and lower thirds.	Not stated.	Not stated.	M.	21	5 months.	Scraping ends with knife.
185	"	"	"	"	M.	21	10 months.	Seton between ends of bone.
186	"	"	"	"	M.	22	17 months.	Resection of both ends, by bone forceps.
187	"	"	"	"	M.	23	2 years.	Refractured partially-united joint, and readjusted it with splints.
188	"	"	"	"	M.	29	5 months.	Drilling both ends, and two ivory pegs driven in.
189	"	"	"	Oblique.	M.	40	6 months.	Seton, between ends of bone.
190	"	"	"	"	M.	40	14 months.	Resection; drilling, and wired together.
191	"	"	Compound, comminuted.	Not stated.	M.	Ad.	4 months.	Forcible friction of ends together.
192	"	"	"	"	M.	Ad.	6 months.	Seton, between ends of bone.
193	"	"	"	"	M.	Ad.	10 months.	Periosteum dissected up, drilled as far as medullary cavity, and united the ends by wire.
194	"	"	Not stated.	"	M.	41	11 months.	Resection of both ends; drilling, and wiring, by iron wire.
195	"	"	"	"	M.	45	3 years.	Resection of both ends; drilling, and wiring, by iron wire.
196	"	"	"	Oblique.	M.	41	2 years.	Resection of both ends; drilling, and wiring, by waxed thread.
197	"	Lower third.	"	Not stated.	M.	23	27 months.	Resection of both ends, and wiring together.
198	"	"	"	"	M.	29	9 months.	Immovable apparatus.
199	"	"	"	"	M.	35	12 months.	Swinging angular splint.
200	"	"	"	"	M.	33	9 weeks.	Seton between ends of bone.
201	"	"	"	"	M.	34	14 months.	Resection of both ends.
202	"	"	Simple.	Oblique.	M.	24	6 months.	Drilling ends, and repeating op. four times, at intervals of seven days.
203	"	"	Not stated.	Not stated.	M.	30	7 months.	Drilling ends, and repeating at intervals.
204	"	"	"	"	M.	33	3 years.	Scraping ends, drilling them, and wiring together.
205	"	"	"	Oblique.	M.	35	4½ months.	Drilling ends at intervals of ten, thirteen, and seventeen days.
206	"	"	"	"	M.	35	8 months.	Seton, between ends of bone.
207	"	"	Compound.	Not stated.	M.	30	8½ months.	" " " "
208	"	"	Not stated.	Very oblique.	M.	43	18 months.	Scraping ends of bone.
209	"	"	"	Not stated.	M.	41	7 weeks.	Pasteboard, from shoulder to fingers, and covered with starch bandage.
210	"	"	"	"	M.	25	10 months.	Wire, wrapped around bones, to excite periosteal inflammation.
211	"	"	"	"	M.	25	More than a year.	Resection of each end, and, some time afterwards, seton.
212	"	"	"	"	M.	27	Not stated.	Resection of both ends.
213	"	"	"	"	M.	Ad.	24 months.	Resection, drilling, and union by wire.
214	"	"	"	"	M.	23	15 months.	Driving into ends two ivory pegs, and breaking up interposed fibrous mass.
215	"	"	"	"	M.	25	2 years.	Two setons, between the ends.
216	"	"	Compound.	"	F.	46	6½ months.	Resection of the ends, drilling, and union by silver wire.
217	"	"	Not stated.	"	M.	19	9 weeks.	Forcible friction of the ends, repeated twice; pasteboard bandage.
218	"	"	Gunshot.	"	M.	28	18 months.	Resection.
219	"	"	Not stated.	"	M.	37	13 months.	Resection of both ends.
220	"	"	Compound.	"	F.	6	9 months.	Resection of both ends, and two steel screws driven in.
221	"	"	External condyle; also pseudarthrosed.	"	M.	36	6 months.	Extraction of loose external condyle; compression, and immovable apparatus.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
184	Subcutan.	Not stated.	....	6 weeks.	Failed.	J. Spence.	Pressure.	Edinburgh Med. Jour., vol. i., 1855–56.
185	"	"	Some days	Some wks.	"	"	Pressure, and scraping	Edinburgh Med. Jour., vol. i., 1855–56.
186	Cut down.	Partial union; used arm too soon.	....	6 weeks.	Relieved.	"	Pressure, scraping, and seton.	Edinburgh Med. Jour., vol. i., 1855–56.
187	....	Not stated.	....	2 months.	Cured.	"	Pressure, scraping, seton, and resection.	Edinburgh Med. Jour., vol. i., 1855–56.
188	Cut down.	"	....	2½ mos.	"	J. Birkett.	Not stated.	London Lancet, vol. i., May 25, 1867.
189	Subcutan.	"	7 months.	7 months.	Failed.	W. A. Gott.	"	American Jour. Med. Sci., Jan. 1870.
190	Cut down.	"	10 weeks.	3½ mos.	Cured.	"	Seton.	American Jour. Med. Sci., Jan. 1870.
191	....	Consider'ble swelling.	....	3 weeks.	Failed.	H. Clarke.	Not stated.	Boston Med. and Surg. Jour., Oct. 18, 1860.
192	Subcutan.	Not stated.	8 days.	4 months.	"	"	Friction, blisters.	Boston Med. and Surg. Jour., Oct. 18, 1860.
193	Cut down.	"	20 days.	5 months.	Cured.	"	Seton, friction, blisters.	Boston Med. and Surg. Jour., Oct. 18, 1860.
194	"	Piece of wire remained in.	Not stated	9 weeks.	Failed.	A. C. Post.	Not stated.	New York Medical Times, July, 1856.
195	"	Erysipelas.	....	4 months.	"	Finnell.	....	New York American Med. Times, 1861.
196	"	Union progressing.	3 weeks.	6 weeks.	Relieved.	M. Laugier.	Seton twice, scraping.	London Lancet, Sept. 1855.
197	"	Union not absolutely firm.	2 months.	4 months.	"	G. Callender.	Not stated.	London Medico-Chirurg. Trans., vol. li., 1868.
198	....	Ligamentous union.	....	"	"	"	"	London Medico-Chirurg. Trans., vol. li., 1868.
199	....	Not stated.	....	3 months.	Cured.	J. Paget.	"	London Medico-Chirurg. Trans., vol. li., 1868.
200	Subcutan.	"	5 weeks.	"	Failed.	Not stated.	"	Edinburgh Medical Jour., Jan.–June, 1857.
201	Cut down.	"	....	6 weeks.	Cured.	J Syme.	Seton.	Edinburgh Medical Jour., Jan.–June, 1857.
202	Subcutan.	"	....	"	"	D. Brainard.	Splints for 3 months.	Chicago Med. Jour., Sept. 1858.
203	"	"	....	"	Failed.	Not stated.	Not stated.	American Jour. Med. Sci., April, 1860.
204	Cut down.	Pain and swelling.	39 days.	5½ mos.	Cured.	E. K. Sanborn.	Drilling, seton.	American Jour. Med. Sci., April, 1860.
205	Subcutan.	Not stated.	....	3 months.	Failed.	C. S. Fenner.	Friction.	American Jour. Med. Sci., April, 1860.
206	"	Much swelling.	23 days.	4 weeks.	"	"	Friction and drilling.	American Jour. Med. Sci., April, 1860.
207	"	Suppuration	13 weeks.	3 months.	"	E. Warren.	Drilling.	American Jour. Med. Sci., April, 1860.
208	"	Erysipelas.	....	Not stated	"	Blandin.	Not stated.	Gazette des Hôpitaux, 1844.
209	....	Not stated.	....	8 weeks.	Cured.	J. Syme.	"	Syme's Observations in Clinical Surgery.
210	Cut down.	"	....	Not stated	Failed.	Key.	"	Cooper on Dislocations and Fractures, p. 575.
211	"	"	Not stated	Weeks.	"	"	Wire, as seton.	Cooper on Dislocations and Fractures, p. 575.
212	"	"	....	18 weeks.	Cured.	Von Textor.	Friction, seton.	Wiederzeugung Knoch. u. Resect., 1842 (Gurlt's Surgery).
213	"	"	49 days.	Not stated	Failed.	Velpeau.	Not stated.	Gazette des Hôpitaux, p. 281, 1850.
214	"	"	13 days.	8 months.	Cured.	Uhde.	"	Deutsche Klinik, p. 210, 1855.
215	"	"	8 days.	5 weeks.	Failed.	Buron.	"	Deutsche Klinik, p. 230, 1853.
216	"	"	5 weeks.	8 weeks.	"	Von Bruns.	"	Deutsche Klinik, Beob. 27, p. 184, 1861.
217	....	"	....	4 months.	Cured.	Weikert.	"	Deutsche Klinik, p. 22, 1854
218	Cut down.	"	....	Not stated	Not stated	Hysern.	"	Velpeau, Med. Operat., t. i., p. 10.
219	"	"	....	7 months.	Cured.	Meinecke.	Friction.	Casper's Wochenschrift, p. 266, 1848.
220	"	No reaction.	3 weeks.	"	Failed.	B. Langenbeck.	Not stated.	Deutsche Klinik, p. 264, 1854.
221	....	Not stated.	....	4 months.	Cured.	J. Paul.	"	Zeitschrift Klin. Med. Jahrg. (Günsburg's) (Gurlt's Surg.), i. p. 138.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
222	Humerus.	Lower third.	Compound.	Not stated.	F.	44	7 months.	Seton, between ends of bone.
223	"	"	"	"	F.	45	18 months.	Periosteum reflected, ends resected, drilled, and wired together.
224	"	"	"	"	M.	28	2½ years.	Firm pressure by external apparatus; forcing ends together.
225	"	"	Not stated.	"	M.	28	31 months.	Seton, between ends of bone.
226	"	"	"	"	M.	30	43 months.	Common turkey's quill placed between ends, and left in.
227	"	"	Simple.	Oblique.	M.	24	4 months.	Forcible friction of ends together.
228	"	"	"	"	M.	24	8 months.	Periosteum reflected, ends resected; drilled into medullary cavity only, and wired ends together.
229	"	"	Not stated.	"	M.	30	2 months.	Forcible friction of ends together.
230	"	"	"	"	M.	31	14 months.	Seton, around fracture, but not between; starch bandage.
231	"	"	"	"	M.	31	17 months.	Glue bandage, as an immovable dressing.
232	"	"	Compound.	Not stated.	M.	23	9 months.	Drilling ends of bone, and two ivory pegs driven in.
233	"	"	Not stated.	"	M.	22	11 months.	Drilling both ends, and operation repeated in three weeks.
234	"	"	"	"	M.	22	12½ mos.	Resection of both ends, drilling, and wiring them together.
235	"	"	"	Oblique.	M.	32	27 months.	Resection of both ends, drilling, and ends wired together by silver wire.
236	"	"	"	Not stated.	M.	Ad.	2 years.	Resection both ends, and angular splint.
237	"	Through condyles.	Double fracture, one 4½ inches, above external condyle down to above internal condyle; other, 2½ inches above external condyle to within joint.	Oblique.	M.	44	9 months.	Drilling, by transfixing with two drills, and these left in.
238	Radius and ulna.	Not stated.	Not stated.	Not stated.	M.	23	4 months.	Forcible friction of ends together.
239	"	"	"	"	M.	23	5 months.	Acupuncture by three needles, introduced daily for three weeks, and then, every other day, for another week. Immovable dressing.
240	"	"	"	"	M.	59	9 weeks.	Immovable dressing, by starch bandage.
241	"	"	"	"	M.	Ad.	Not stated.	Resection, and bones united by wire ligature.
242	"	"	"	"	M.	Ad.	"	Resection, and bones united by wire ligature.
243	"	"	Compound, by circular saw.	Transverse.	M.	20	4 months.	Resection both ends of ulna, drilling, and wiring them together.
244	"	"	Compound.	"	M.	22	4 months.	Forcible friction of ends together.
245	"	"	"	"	M.	22	18½ weeks.	Resection both ends of ulna, drilling, and uniting by iron wire.
246	"	"	Not stated.	Not stated.	F.	20	4 months.	Resection of upper end.
247	"	"	"	"	M.	Ad.	2 years.	Resection of both ends.
248	"	"	Simple.	"	M.	13	60 days.	Boyer's apparatus, and tonics.
249	"	"	Comminuted.	"	M.	30	12 months.	Drilling each end, and pegs driven in.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
222	Subcutan.	Not stated.	4 weeks.	Not stated	Failed.	Not stated.	Not stated.	Boston Medical and Surg. Jour., May, 1867.
223	Cut down.	"	4½ mos.	5 months.	"	H. J. Bigelow.	Seton.	Boston Medical and Surg. Jour., May, 1867.
224	....	"	....	4 weeks.	"	H. Barnes.	Not stated.	Boston Medical and Surg. Jour., Feb. 25, 1858.
225	Subcutan.	"	11 mos.	11 mos.	"	"	Pressure.	Boston Medical and Surg. Jour., Feb. 25, 1858.
226	"	"	5 weeks.	6 weeks.	Cured.	"	Pressure and seton.	Boston Medical and Surg. Jour., Feb. 25, 1858.
227	....	....	....	4 months.	Failed.	Not stated.	Splints.	Boston Medical and Surg. Jour., Feb. 25, 1858.
228	Cut down.	"Musculo-spiral nerve divided, except a small fasciculus; motion and sensation restored to hand."	6 mos.	6 months.	Cured.	H. J. Bigelow.	Friction.	Boston Medical and Surg. Jour., Feb. 25, 1858.
229	....	Not stated.	....	2 months.	Failed.	Not stated.	Not stated.	Dublin Jour. Med. Science, vol. iv., 1847.
230	Subcutan.	Inflammation.	34 days.	9 weeks.	"	F. Rynd.	Friction.	Dublin Jour. Med. Science, vol. iv., 1847.
231	....	Not stated.	....	3 months.	Cured.	Not stated.	Friction and seton.	Dublin Jour. Med. Science, vol. iv., 1847.
232	Cut down.	Abscess.	7 weeks.	10 weeks.	"	E. Hutton.	Not stated.	Dublin Hospital Gazette, Feb. 15, 1854.
233	Subcutan.	Not stated.	....	6 weeks.	Failed.	S. D. Gross.	"	Louisville, Ky., Review, July, 1856.
234	Cut down.	"	3 months.	3 months.	Cured.	"	Drilling.	Louisville, Ky., Review, July, 1856.
235	"	Union was almost complete 4 months after operation.	....	4 months.	Relieved.	"	Not stated.	North Amer. Med.-Chirur. Review, July, 1861.
236	"	Splint on 10 weeks.	....	4 months.	Cured.	C. Puzey.	"	Liverpool Med. and Surg. Reports, vol. i., 1867.
237	Subcutan.	Not stated.	Upper 15 days, lower 22 days.	10 weeks.	"	Fletcher.	"	London Medico-Chirurg. Trans., vol. xlvii., 1864.
238	....	"	....	4 weeks.	Failed.	W. J. Moore.	"	British Medical Journal, July, 1859.
239	Subcutan.	"	....	Some wks	Cured.	"	Friction.	British Medical Journal, July, 1859.
240	....	"	....	4 months.	Failed.	Not stated.	Not stated.	Boston Med. and Surg. Jour., May 16, 1867.
241	Cut down.	"	....	Not stated	Cured.	"	"	New York Medical Times, Oct. 1851.
242	"	"	....	6 months.	Failed.	"	"	New York Medical Times, Oct. 1851.
243	"	Profuse suppuration.	Not stated	7 months.	Cured.	A. C. Post.	"	New York Medical Times, Oct. 1851.
244	....	Not stated.	....	5½ weeks	Failed.	"	"	New York Medical Times, July, 1856.
245	Cut down.	Suppuration.	Wire remained in.	6 months.	Cured.	"	Friction.	New York Medical Times, July, 1856.
246	"	Not stated.	....	8 weeks.	Relieved.	Wardrop.	Not stated.	Edinburgh Med. and Surg. Jour., vol. i., 1805.
247	"	Small fistula.	....	Not stated	Cured.	Verneuil.	"	Gazette des Hôpitaux, 1857, p. 276.
248	....	Not stated.	....	9 weeks.	"	A. Thierry.	"	L'Expérience, Nov. 4, 1841.
249	Cut down.	Consolidation to a great extent established in 3 weeks.	2 weeks.	Not stated	Relieved.	W. Ferguson.	"	London Lancet, Oct. 1852.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed
250	Radius and ulna.	Not stated.	Compound.	Not stated.	M.	46	10½ mos.	Acupuncture by one needle, inserted every four days, for a short time.
251	"	"	Not stated.	"	M.	29	5 weeks.	Perfect rest and tonic treatment.
252	"	"	"	"	M.	Ad.	Not stated.	Firm and continued pressure.
253	"	Junction of upper and middle thirds	"	Oblique.	M.	31	16 months.	Resection of both ends of bone.
254	"	"	"	"	M.	43	15 months.	" " " "
255	"	"	"	"	M.	43	18 months.	Resection of ends, and united by twisted silver wire.
256	"	Upper and middle thirds	"	"	M.	22	3 months.	Ends of the fragments resected and wired together.
257	"	Middle third.	"	Not stated.	M.	32	11 months.	Drilling both ends, and repeated in five weeks.
258	"	"	"	"	M.	33	21 months.	Resection of both ends of bone.
259	"	"	"	"	F.	32	4 months.	Forcible friction of ends, and very careful adjustment of splints.
260	"	"	"	"	F.	32	5 months.	Acupuncture by three needles, introduced daily for three weeks, and then every other day for another week.
261	"	Middle.	Compound.	Oblique.	M.	21	6½ months.	Resection of both ends, drilled, and wired together.
262	"	"	Not stated.	Not stated.	M.	32	10 months.	Drilling both ends, and repeated in third week, and again in the tenth week.
263	"	"	"	"	M.	33	21 months.	Resection of both ends of bone.
264	"	"	"	"	F.	18	12 weeks.	Forcible breaking up of interposed fibrous mass, and compression on wooden splint.
265	"	"	"	"	M.	25	6 months.	Resection of one end.
266	"	"	"	"	M.	29	13 months.	Acupuncture by two long needles between ends of ulna, and three needles between ends of radius.
267	"	"	Crushed.	"	F.	26	10 months.	Three setons of ten or twelve silk threads, and starch bandage in fourth week.
268	"	Junction of middle and lower thirds.	Compound.	"	M.	30	5 months.	Resection of both ends of bone.
269	"	"	Not stated.	"	M.	37	10 months.	Resection of both ends of radius; paste bandage.
270	"	"	Compound.	Oblique.	M.	19	17 weeks.	Firm bandaging, splints, and tonics.
271	"	"	"	"	M.	19	25 weeks.	Tincture of iodine and other stimulants locally.
272	"	"	"	"	M.	19	34 weeks.	Resection of both ends and dextrine bandage.
273	"	Lower third.	"	Not stated.	M.	......	4 years.	Drilling each end and pegs driven in.
274	"	"	"	"	M	......	Over 4 yrs.	Scraping ends of bone with narrow chisel, and repeated twice.
275	Radius.	Not stated.	Not stated.	"	M.	Ad.	12 months.	Periosteum dissected up for an inch and removed from sides of each end without disturbing fragments; parts canterized with hot iron.
276	"	"	"	"	M.	26	11 weeks.	Acupuncture by several needles, which were left in.
277	"	"	"	"	M.	60	Not stated.	Resection, drilled, and union by gold thread.
278	"	"	"	"	M.	26	19 weeks.	Resection of ends.
279	"	"	"	"	M.	Ad.	Not stated.	" "
280	"	"	"	"	F.	Ad.	"	" "
281	"	"	"	"	M.	56	8 weeks.	Acupuncture by one long needle, for fifteen minutes, every three or four days, during a period of five weeks.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
250	Subcutan.	Ulna united but not radius.	....	9 weeks.	Relieved.	G. B. Günther.	Not stated.	F. Gruner's Dissertation on Curing Pseudarthrosis, Leipsic, 1852, p. 5.
251	....	Not stated.	....	11 weeks.	Cured.	G. Buck.	"	Transac. N. Y. Academy Med., vol. i., 1847–59.
252	....	"	....	3 months.	"	Rust.	"	Journal des Progrès, t. x. p. 259.
253	Cut down.	"	....	5 months.	"	A. Legat.	Splints.	Edinburgh Med. Journ., July, 1858.
254	"	Muscular fibres found between ends of bone.	....	3 months.	Failed.	S. J. Jones.	Not stated.	Amer. Jour. Med. Sciences, July, 1866.
255	"	Not stated.	....	3 months.	Cured.	"	Resection.	Amer. Jour. Med. Sciences, July, 1866.
256	....	"	108 and 124 days.	4 months.	"	M. H. Packard.	None.	Amer. Jour. Med. Sciences, July, 1875.
257	Subcutan.	Abscess.	....	16½ wks.	Failed.	R. A. Kinlock.	Not stated.	Amer. Jour. Med. Sciences, Jan. 1859.
258	Cut down.	Much suppuration.	....	14 weeks.	"	"	"	Amer. Jour. Med Sciences, Jan. 1859.
259	....	Not stated.	....	3 weeks.	"	W. J. Moore.	"	British Medical Journal, July, 1859.
260	Subcutan.	"	....	3 months.	Cured.	"	Friction.	British Medical Journal, July, 1859.
261	Cut down.	Erysipelas.	8 weeks.	6 months.	Failed.	J. K. Rodgers.	Not stated.	New York Medical Times, Oct. 1851.
262	Subcutan.	Not stated.	....	20 weeks.	"	R. A. Kinlock.	"	Amer. Jour. Med. Sciences, Jan. 1859.
263	Cut down.	"	....	14 weeks.	"	"	Drilling.	Amer. Jour. Med. Sciences, Jan. 1859.
264	....	"	....	18 days.	Cured.	Von Bruns.	Not stated.	Deutsche Klinik, 1861, p. 174.
265	....	"	....	Not stated	"	Jobert (de Lamballe).	Two setons.	Gazette des Hôpitaux, p. 469, 1847.
266	Subcutan.	"	5 days.	6 weeks.	"	H. Wiefel.	Not stated.	Casper's Wochenschrift, 1843, p. 626.
267	Subcutan.	Suppuration	Not stated	14 weeks.	"	Houston.	Not stated.	Dublin Med. Press, May 1, 1844.
268	Cut down.	Not stated.	....	18 weeks.	"	G. May.	Seton, compression, friction, ptyalism.	London Med. Gazette, vol. iii., 1846.
269	"	"	....	12 weeks.	"	W. Günter.	Not stated.	Vierteljahresschrift Prakt. Heilk., Jahrg. 16, 1859, Bd. ii. (Gurlt.)
270	....	"	....	2 months.	Failed.	W. B. Page.	"	London Medico-Chirurg. Trans., vol. xxxi., 1848.
271	....	"	....	9 weeks.	"	"	Splints.	London Medico-Chirurg. Trans., vol. xxxi., 1848.
272	Cut down.	Abscess.	....	3 months.	Cured.	"	Iodine and pressure.	London Medico-Chirurg. Trans., vol. xxxi., 1848.
273	Subcutan.	Great suppuration.	9 days.	Not stated	Failed.	Geoghegan.	Pressure, seton.	London Lancet, October, 1852.
274	"	Much inflammation.	....	"Some time."	"	"	Pressure, seton, and ivory pegs	London Lancet, October, 1852.
275	Cut down.	Not stated.	....	3 months.	Cured.	Edfond.	Not stated.	Velpeau's Surgery.
276	Subcutan.	"	6 days.	4 weeks.	"	Wiesel.	"	Gazette des Hôpitaux, Nov. 1843.
277	Cut down.	"	....	177 days.	"	Wutzer.	"	Weber, Chirurg. Erfahrung. und Untersuch. (Gurlt's Surgery.)
278	"	"	....	Not stated	"	Not stated.	"	Malgaigne on Fractures (Packard), 1859, p. 261.
279	"	"	....	"	"	Dupuytren.	"	Bérard on Causes retarding Consolid. Fractures, 1833.
280	"	"	....	7 weeks.	"	Holscher.	"	Rust's Handbuch d. Chirg., Bd. vi., 1832, p. 544. (Gurlt's Surgery.)
281	Subcutan.	"	....	"	"	G. B. Günther.	"	Gruner on Method of Curing False Joint, 1852. (Gurlt's Surgery.)

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
282	Radius.	Not stated.	Not stated.	Not stated.	M.	52	9 months.	Resection of both ends, drilling, and wiring together.
283	"	"	"	"	M.	56	4 years.	Periosteum dissected up and reflected; resection of both ends; drilling them into medullary cavity only, and wired together.
284	"	"	"	"	M.	Ad.	Not stated.	Drilling each end, and wired together.
285	"	Upper third.	Simple.	Oblique.	M.	33	8 months.	Seton between ends of bone, and repeated in eight weeks.
286	"	"	"	"	M.	33	12 months.	Drilling ends, and united by silver wire.
287	"	"	"	Not stated.	F.	47	2 years.	Diagonal resection of overlapped bone, drilled diagonally, needle passed through, and wire thrown around in figure of 8.
288	"	"	Not stated.	"	M.	30	4½ years.	Resection of both ends of bone.
289	"	Middle.	"	"	M.	15	Some mos.	Acupuncture by three needles, introduced daily, between ends, or every other day, for eight or nine weeks. Immovable dressing.
290	"	"	"	"	M.	24	12 months.	Seton.
291	"	Junction of middle and lower thirds.	Simple.	"	M.	26	8 months.	Drilling both ends, and repeated in thirteen days, and again in twenty-two days.
292	"	"	"	Oblique.	M.	26	3 months.	Carved splints.
293	"	Lower third.	Not stated.	"	M.	26	16 weeks.	Seton between ends of bone.
294	"	"	Comminuted.	Not stated.	F.	23	7 weeks.	Splints and tonics.
295	"	"	Not stated.	"	M.	35	11 months.	Scraping periosteum from both ends for half an inch.
296	"	"	"	"	M.	40	11 months.	Resection of both ends.
297	"	"	Comminuted.	"	M.	35	6 months.	Resection of both ends, and, with cutting forceps, breaking up mass between rad us and ulna.
298	Ulna.	Not stated.	Compound, comminuted.	"	M.	60	7 months.	Forcible friction of ends together, and starch bandage.
299	"	"	"	"	M.	60	8½ months.	Scraping periosteum from the sides of ends for an inch from upper fragment; same thing done in three weeks on lower fragment.
300	"	"	Not stated.	"	M.	26	16 months.	Resection of both ends.
301	"	"	"	"	F.	19	Not stated.	" "
302	"	"	"	Oblique.	M.	23	10 weeks.	Tincture of iodine externally at point of fracture.
303	"	"	Compound.	Not stated.	M.	Ad.	3 months.	Drilling ends of bone, and repeated in twelve days.
304	"	"	Not stated.	"	M.	Ad.	Months.	Tenotomy of tendon of triceps, and friction of ends every two weeks.
305	"	"	"	"	M.	26	9 weeks.	Acupuncture with two needles between ends and left in.
306	"	Upper third, into sigmoid cavity, and downwards two inches.	"	"	M.	35	18 weeks.	Drilling ends, and repeated in twelve days.
307	"	Upper third.	"	"	M.	39	8 months.	Resection of both ends of bone.
308	"	Middle third.	"	"	M.	30	4 years.	Pressure with oval pad over fracture, and broad splint on palmar surface of forearm.
309	"	Middle.	Simple.	Oblique.	M.	48	2½ months.	Forcible friction of ends together, and leathern strapping.
310	"	"	Compound.	"	M.	36	8 weeks.	Drilling ends of bone, and repeated in eleven days, and again in five days.
311	"	Junction of middle and lower thirds.	Simple.	Not stated.	M.	33	8 months.	Drilling ends of bone, and repeated in eight weeks.
312	"	"	"	"	M.	33	15 months.	Drilling ends of bone, and wired together with silver wire.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
282	Cut down.	Not stated.	....	Some time	Failed.	Not stated.	Starch bandage.	Boston Medical and Surg. Jour., May 16, 1867.
283	"	Pain and swelling.	"2 years."	6 weeks.	Cured.	H. J. Bigelow.	Resection.	Boston Medical and Surg. Jour., May 16, 1867.
284	"	"In withdrawing wire broke the bone."	8 weeks.	8 weeks.	Failed.	E. R. Bickersteth.	Not stated.	Lond. Lancet, vol. i., 1864.
285	Subcutan.	Erysipelas.	4 days.	3 months.	"	Not stated.	"	Amer. Jour. Med. Sci., July, 1859.
286	Cut down.	Abscess.	5½ wks.	8 weeks.	Cured.	E. K. Sanborn.	"	Amer. Jour. Med. Sci., July, 1859.
287	"	No bad symptoms.	7 weeks.	Not stated	"	F. Mason.	"	Lond. Med.-Chirur. Trans., vol. lxiv., 1871.
288	"	Phlegmonous erysipelas.	....	6 weeks.	"	C. S. Tripler.	"	Maryland Med. and Surg. Jour., Sept. 1842.
289	Subcutan.	Not stated.	....	2 months.	"	W. J. Moore.	"	British Medical Journal, July, 1859.
290	"	"	Not stated	9 weeks.	"	Da Camin.	"	Annal. Universal. d. Med., 1857, ser. 4, vol. xxv. (Gurlt's Surgery.)
291	"	"	....	7 weeks.	"	D. Brainard.	Seton.	New Western Medical and Surg. Jour., March, 1852.
292	....	"	....	4 weeks.	Failed.	White.	Not stated.	New Western Medical and Surg. Jour., March, 1852.
293	Subcutan.	Much suppuration.	3 weeks.	9 weeks.	"	"	Splints.	New Western Medical and Surg. Jour., March, 1852.
294	....	When first seen was in seventh month of pregnancy	....	8 weeks.	Cured.	J. W. S. Gouley.	Not stated.	N. Y. Amer. Medical Times, Nov. 1860.
295	Cut down.	Not stated.	....	3 months.	"	E. Ford.	"	London Medical Journal, vol. ii., 1782, p. 46.
296	"	Ligation of brachial artery.	....	Not stated	Failed.	Roux.	"	Ann. de Thérap., Méd. et Chirurg., 1847, p. 383.
297	"	Not stated.	....	4 weeks.	Cured.	J. Pancoast.	"	Phila Med. and Surg. Reporter, 1859, vol. ii. p. 111.
298	....	"	....	6 weeks.	Failed.	J. Duncan.	"	Edinburgh Med. Journal, Jan. to June, 1867.
299	Subcutan.	"	....	3 months.	Cured.	"	Friction.	Edinburgh Med. Journal, Jan. to June, 1867.
300	Cut down.	"	....	Not stated	Not stated.	Partridge.	Not stated.	Lond. Lancet, 1856, vol. i.
301	"	"	....	"	Failed.	Warmuth.	"	Rust's Handbuch d. Chir., 1832, Bd. vi. (Gurlt's Sur.)
302	....	"	....	11 weeks.	Cured.	Trusen.	"	Med. Zeitung Vereins f. Heilk. in Prakt. (Gurlt's Surgery), 1834, p. 114.
303	Subcutan.	"	....	3 weeks.	"	D. Brainard.	"	Chicago Med. Jour., Sept. 1858.
304	"	....	....	3 months.	"	Dieffenbach.	"	Casper's Wochenschrift, Oct. 2, 1841.
305	"	Pain and swelling.	6 days.	6 weeks.	"	Wiesel.	"	Gazette des Hôpitaux, Nov 1843.
306	"	Not stated.	....	4 weeks.	"	D. Brainard.	"	Trans. Amer. Med. Asso., vol. vii., 1854.
307	Cut down.	Three attacks erysipelas.	....	4½ mos.	Failed.	G. W. Norris.	"	Amer. Jour. Med. Sci., Jan. 1843.
308	....	Great pain.	....	11 weeks.	Cured.	C. S. Tripler.	"	Maryland Med. and Surg. Jour., Sept. 1842.
309	....	Not stated.	....	9 weeks.	"	J. D. Hill.	"	Lond. Lancet, vol. i., 1868.
310	Subcutan.	"	....	7 weeks.	"	D. Brainard.	"	Trans. Amer. Med. Asso., vol. vii., 1854.
311	"	"	....	3 months.	Failed.	Not stated.	"	Amer. Jour. Med. Sci., July, 1859.
312	Cut down.	"	4 weeks.	5 weeks.	Cured.	E. K. Sanborn.	Drilling.	Amer. Jour. Med. Sci., July, 1859.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
313	Ulna.	Lower third.	Compound.	Not stated.	F.	47	2 years.	Resection of ends diagonally, drilling these obliquely, needle passed through and loop of wire twisted around it. Needle left in.
314	Metacarpus.	Middle finger.	Not stated.	"	M.	Ad.	Some weeks.	Acupuncture, with several needles between ends of bone, daily for some time.
315	Eighth rib.	Middle.	"	"	M.	Ad.	2 years.	Resection ends by strong bone-forceps.
316	Femur.	Not stated.	"	Transverse.	M.	Ad.	5 months.	Forcible friction of ends together.
317	"	"	"	Not stated.	M.	Ad.	3 months.	Malgaigne's spikes.
318	"	"	"	"	M	Ad.	10 weeks.	Extension by five-pound weight, and occasionally walking about on limb so as to produce friction.
319	"	"	"	"	M.	Ad.	Not stated.	Drilling ends, and plaster-of-Paris dressing.
320	"	"	"	"	M.	Ad.	Some time.	Drilling ends, and drill left in.
321	"	"	"	"	M.	Ad.	9 months.	Seton, from before backwards.
322	"	"	"	"	M.	Ad.	Not stated.	Seton, between ends.
323	"	"	"	"	M.	32	96 days.	Starch bandage and flexible splints.
324	"	"	"	"	M.	32	5½ months.	Firm pressure by "grande cuirasse."
325	"	"	"	"	M.	32	7 months.	" " " "
326	"	"	"	Oblique.	M.	Ad.	10 months.	Dextrine bandage and pasteboard splints.
327	"	"	"	Not stated.	F.	39	Months.	Immovable dressing of starch.
328	"	"	"	"	F.	33	15 months.	Drilling ends, and ivory pegs driven in.
329	"	"	"	"	M.	Ad.	Not stated.	Drilling ends of bone, and drill left in.
330	"	"	"	"	Ch.	2½ yrs.	5 weeks.	Long outside splint, with gutta-percha thigh-piece.
331	"	"	"	"	M.	23	13 weeks.	Compound tincture of iodine locally, night and morning.
332	"	"	"	"	M.	48	14 weeks.	Stirring up with needle the interposed mass and scraping the ends.
333	"	"	2½ inches shortening.	"	M.	54	20 months.	Dzonde's apparatus.
334	"	"	Not stated.	"	M.	13	7 weeks.	Tincture of iodine locally.
335	"	"	"	"	M.	30	10 weeks.	" " "
336	"	"	"	"	M.	19	12 weeks.	" " "
337	"	"	"	"	M.	23	13 weeks.	" " "
338	"	"	"	"	M.	28	15 weeks.	" " "
339	"	"	"	"	M.	Ad.	Some wks.	Acupuncture by several needles passed between ends daily.
340	"	"	Comminuted.	"	M.	Ad.	Not stated.	Tincture of iodine locally and internally, ptyalism, and starch bandage.
341	"	"	Compound.	"	F.	33	7 months.	Firm pressure.
342	"	"	"	"	F.	33	8 months.	Rest and compression.
343	"	"	"	"	F.	33	11 months.	Seton, between ends.
344	"	"	Simple.	Oblique.	M.	56	4 months.	Drilling ends, and repeated three times, at intervals of eight, ten, and twelve days
345	"	"	"	Not stated.	M.	Ad.	4 months.	Drilling ends, and repeated twice, at intervals of eight and ten days.
346	"	"	Not stated.	"	M.	45	18 weeks.	Tourniquet and firm bandaging.
347	"	"	"	"	M.	4	10 weeks.	Inclined plane.
348	"	"	"	"	M.	35	Not stated.	Pressure and gradual permanent extension.
349	"	"	"	"	M.	58	19 weeks.	Swinging apparatus of Middledorps.
350	"	"	"	"	M.	49	4½ months.	" " "

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
313	....	No bad symptoms.	7 weeks.	9 weeks.	Cured.	F. Mason.	Pressure.	Lond. Med.-Chirur. Trans., vol. liv., 1871.
314	Subcutan.	Not stated.	....	Not stated	"	W. J. Moore.	Ball in palm of hand.	British Medical Journal, July, 1859.
315	Cut down.	"	....	7 months.	"	P. F. Eve.	Not stated.	Nashville Med. and Surg. Jour., Nov. 1855.
316	....	"	....	3 weeks.	"	E. M. Moore.	"	Trans. Amer. Med. Asso., vol. xxiii., 1872.
317	....	"	....	Not stated	"	"	"	Trans. Amer. Med. Asso., vol. xxiii., 1872.
318	....	"	....	Some time	Failed.	G. Buck.	"	Trans. Amer. Med. Asso., vol. xxiii., 1872.
319	Subcutan.	"	....	Not stated	"	"	Friction.	Trans. Amer. Med. Asso., vol. xxiii., 1872.
320	"	"	Some time	"	Cured.	"	Friction and drilling.	Trans. Amer. Med. Asso., vol. xxiii., 1872.
321	"	Pyæmia.	3 weeks.	3 weeks.	Died.	Peace.	Not stated.	Norris, Contributions to Surgery, 1873.
322	"	Not stated.	Consid. time.	Not stated	Failed.	B. Brodie.	"	Brodie's Pathology and Surgery.
323	....	"	....	2 months.	"	M. Bonnet.	"	Gaz. Médicale, Sept. 1839.
324	....	"	....	7 weeks.	Cured.	"	Immovable dressing.	" "
325	....	"	....	3½ mos.	"	"	Immovable dressing and pressure.	" "
326	....	"	....	2 months.	"	A. L. M. Velpeau.	Not stated.	Velpeau's Surgery.
327	....	....	....	Not stated	"	"	"	" "
328	Subcutan.	....	10 days.	3 months.	"	Dieffenbach.	"	Casper's Wochenschrift, 1846, p. 732.
329	Cut down.	Suppuration, pneumonia.	2½ mos.	2½ mos.	Died.	E. R. Bickersteth.	"	London Lancet, vol. i., 1864.
330	....	Not stated.	....	59 days.	Cured.	Not stated.	"	St. Thomas's Hosp. Statistical Reports, 1864.
331	....	"	....	3 weeks.	"	Blasius.	"	Med. Zeitung, No. 39, 1851.
332	Subcutan.	Refractured in fourth month.	....	5½ mos.	Failed.	J. Miller.	"	Dublin Med. Press, June 21, 1848.
333	....	Not stated.	....	8 weeks.	Cured.	Blasius.	"	Med. Zeitung, 1847, p. 44.
334	....	"	....	4 weeks.	"	Hodanu.	"	Günsburg's Zeitschr. Klin. Med., Jahr. 1, 1850, p. 275.
335	....	"	....	12 days.	"	"	"	Günsburg's Zeitschr. Klin. Med., Jahr. 1, 1850, p. 275.
336	....	"	....	2 weeks.	"	"	"	Günsburg's Zeitschr. Klin. Med., Jahr. 1, 1850, p. 275.
337	....	"	....	3 weeks.	"	Höpstein.	"	Med. Zeitung, 1851, p. 183.
338	....	"	....	5 weeks.	"	De Leuw, Jr.	"	Med. Zeitung, 1854, p. 42.
339	Subcutan.	"Patient walked too soon and callus gave way."	....	Not stated	Failed.	W. J. Moore.	"	Brit. Med. Jour., July, 1859.
340	....	Not stated.	....	Months.	"	J. Adams.	"	Lond. Med. Times, vol. ii., N. S., 1851.
341	....	"	....	4 weeks.	"	Not stated.	"	American Jour. Med. Sci., Jan. 1849.
342	....	"	....	3 months.	"	G. Fox.	Pressure.	American Jour. Med. Sci., Jan. 1849.
343	Subcutan.	"	4 months.	4 months.	"	"	"	American Jour. Med. Sci., Jan. 1849.
344	"	"	....	6 weeks.	Cured.	D. Brainard.	Not stated.	Chicago Med. Jour., Sept. 1858.
345	"	"	....	8 weeks.	"	Johnson & Brainard.	"	Chicago Med. Jour., Sept. 1858.
346	....	"	....	21 weeks.	"	Not stated.	"	Lon. Med. and Surg. Jour., 1834, vol. iv.
347	....	"	....	8 weeks.	"	J. Paul.	"	Conservative Chirurgie, p. 280. (Gurlt's Surgery.)
348	....	....	....	Not stated	"	Malcolm.	....	Edinburgh Med. and Surg. Jour., 1838, vol. v.
349	....	....	....	5 weeks.	"	Paul & Klose.	....	Conservative Chirurgie, p. 286. (Gurlt's Surgery.)
350	....	....	....	6 weeks.	"	"	Not stated.	Conservative Chirurgie, p. 286. (Gurlt's Surgery.)

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
351	Femur.	Not stated.	Not stated.	Not stated.	M.	Ad.	3 months.	Friction by walking about with leg in splint, hollowed out to fit back of leg, from spine of ilium to bottom of foot, with a joint behind the knee; a firm hollowed splint was applied in front, and the whole secured by straps and buckles.
352	"	"	"	"	M.	72	Not stated.	Walking about in H. H. Smith's apparatus, which retains fracture nearly immovable.
353	"	"	"	"	M.	48	14 weeks.	Scarification of ends; paste bandage.
354	"	"	"	"	M.	60	10 years.	Seton.
355	"	"	"	"	M.	Ad.	Not stated.	Resection.
356	"	"	"	"	F.	Ad.	18 months.	Resection of upper fragment.
357	"	"	"	"	M.	......	Not stated.	Resection of both ends.
358	"	"	"	"	M.	27	18 months.	" " "
359	"	"	"	"	M.	68	6 months.	Resection.
360	"	"	"	"	F.	24	11 months.	Resection of both ends; starch bandage after eight days.
361	"	"	"	"	M.	28	9 months.	Resection.
362	"	"	"	"	M.	......	Not stated.	Resection, and union by gold wire.
363	"	"	"	"	M.	......	"	Resection, and union by four gold wires.
364	"	"	"	"	M.	25	18 months.	Resection of both ends.
365	"	"	"	"	M.	60	Many mos.	" " "
366	"	"	"	"	M.	Ad.	Not stated.	" " "
367	"	"	"	"	F.	25	6 months.	Electro-puncture by acupuncture on each side of fracture three times weekly.
368	"	"	"	"	M.	27	7 months.	Immovable apparatus of leather.
369	"	"	"	"	F.	24	Some time.	Walking about on crutches; starch bandage and tonics.
370	"	"	"	"	M.	Ad.	6 months.	Splints.
371	"	Neck, within capsule.	"	"	M.	74	2 years.	Recumbent position and splints.
372	"	Neck.	"	Oblique.	M.	33	4 months.	Forcible friction of ends, starch bandage, and continued extension.
373	"	"	"	"	M.	33	6 months.	Rest and immovable apparatus.
374	"	"	"	"	M.	33	7 months.	Acupuncture by four needles between ends, and left in.
375	"	"	"	Not stated.	M.	35	4 months.	Starch bandage and gutta-percha splints.
376	"	"	"	"	M.	17	7 weeks.	Compound tincture of iodine, ℳ viij. internally, three times daily for eight days, and long splints.
377	"	"	"	"	M.	Ad.	9 weeks.	Boyer's apparatus, and anti-syphilitic treatment.
378	"	"	"	"	M.	37	6 weeks.	Friction of ends, and starch bandage.
379	"	Upper third.	"	"	M.	45	5 months.	Resection of both ends, drilling, and ivory pegs driven in.
380	"	"	"	"	M.	27	13 months.	Starch bandage.
381	"	"	"	"	M.	27	14 months.	Immovable apparatus, and walking about on crutches.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
351	....	....	....	41 days.	Cured.	R. Moyle.	Not stated.	Lon. Med. Repository, vol. x., 1818.
352	....	....	....	41 days.	Relieved.	H. H. Smith.	"	Amer. Jour. Med. Sci., vol. xxix., 1855.
353	Subcutan.	Union was firm in 3 months, but he fell and re-fractured it.	....	5 months.	Not stated	Liston.	"	Edinburgh Monthly Jour. Med. Sci , vol. viii., 1848.
354	"	....	Short time	Not stated	Cured.	Jobert (de Lamballe).	"	Gazette des Hôpitaux, 1847, p. 90.
355	Cut down.	Operation lasted one hour.	....	Same day.	Died.	Gable.	"	Velpeau's Méd. Opérat., t. i. p. 533.
356	"	Not stated.	....	2 months.	Cured.	Dupuytren.	"	Leçons Orales de Clinique Chirurg., t. ii. p. 488. (Gurlt's Surgery.)
357	"	"	....	Not stated	"	"	"	Bérard on Causes which retard Consolidation of Fractures, p. 51, 1833.
358	"	"	....	"	"	Banner.	"	Edinburgh Med. and Surg. Jour., vol. lix., 1843.
359	"	"	....	14 weeks.	"	Reverdit.	"	Gazette des Hôpitaux, 1843, p. 542.
360	"	"	....	10 mos.	"	Günter.	"	Vierteljahressch. d. Prakt. Heilk., Bd. lxii., 1859. (Gurlt's Surgery.)
361	"	"	....	Not stated	"	Not stated.	"	Malgaigne on Fractures (Packard), p. 261.
362	"	"	....	"	"	N. R. Smith.	"	Malgaigne on Fractures (Packard), p. 255.
363	"	"	....	"	"	"	"	Malgaigne on Fractures (Packard), p. 255.
364	"	Ligated femoral and popliteal artery on 18th day.	....	20 days.	Died.	Wutzer.	"	F. Geller, Dissert. on Resection of False Joint of Femur. (Gurlt's Surg.)
365	"	Not stated.	....	Not stated	Cured.	Moreau.	"	Essay on the Use of Resection, etc., p. 72. (Gurlt's Surgery.)
366	"	"	....	11 mos.	"	Von Dumreicher.	Resection.	Zeitschrift der K. K. Gesellschaft, etc., 1860. (Gurlt's Surgery.)
367	Subcutan.	"	3 months.	4 months.	"	J. Watson.	Not stated.	New York Med. Times, October, 1851.
368	....	"	....	12 weeks.	"	J. A. Paxson.	"	Phila. Med. and Surg. Reporter, Feb. 26, 1870.
369	....	"	....	Some wks.	"	Poland.	"	London Lancet, October, 1852.
370	....	"	....	"	"	Manifold.	"	Liverpool Med. and Surg. Rep., 1870.
371	....	Sloughing of nates.	....	4 weeks.	Died.	A. D. Anderson.	"	Glasgow Medical Journal, vol. i.
372	....	Not stated.	....	2 months.	Failed.	M. Lenoir.	"	Bulletin Général de Thérapeut., Dec. 15, 1850.
373	....	....	....	4 weeks.	"	"	Friction.	Bulletin Général de Thérapeut., Dec. 15, 1850.
374	Subcutan.	Suppuration	Two 6 days; other, 5 days.	11 weeks.	Cured.	"	Friction and immovable dressing.	Bulletin Général de Thérapeut., Dec. 15, 1850.
375	....	Not stated.	....	6 weeks.	"	D. Wooster.	Not stated.	Pacific Medical and Surg. Jour., 1863.
376	....	"	....	3 months.	"	Adams.	"	London Med. Times and Gazette, 1859.
377	....	"	....	4 weeks.	"	A. Thierry.	"	L'Expérience, November 4, 1841.
378	....	"	....	8 weeks.	"	J. G. Bingham.	"	Amer. Jour. Med. Sci., April, 1869.
379	Cut down.	Pyæmia.	6 days.	6 days.	Died.	J. D. Hill.	"	London Lancet, vol. i., 1868.
380	....	Not stated.	....	4 weeks.	Failed.	Stanley.	"	London Lancet, April, 1854.
381	....	"	....	"Number of weeks."	"	"	Starch bandage.	London Lancet, April, 1854.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
382	Femur.	Upper third.	Not stated.	Not stated.	M.	27	20 months.	Resection of both ends, drilling, and three ivory pegs driven in.
383	"	"	Simple.	Oblique.	M.	13	15 months.	Seton around, but not between fracture; starch bandage.
384	"	"	Not stated.	Oblique.	M.	19	8 weeks.	Resection of ends, drilling, and union by silk thread.
385	"	"	Simple.	Not stated.	M.	18	10 weeks.	Extension and counter-extension without splints.
386	"	"	Not stated.	"	M.	55	5 months.	H. H. Smith's apparatus, retaining fracture almost immovable, but allowing patient to walk about.
387	"	"	"	"	M.	38	12 months.	Seton, between ends.
388	"	"	"	Oblique.	M.	20	9 months.	Resection of both ends.
389	"	"	"	Not stated.	M.	53	2 years.	Drilling ends, and united by silver wire.
390	"	"	"	"	F.	16	10 weeks.	Forcible friction of ends, and Physick's modification of Desault's long splint.
391	"	"	"	"	M.	Ad.	6 months.	H. H. Smith's apparatus, allowing patient to walk about, but retaining fracture almost immovable.
392	"	"	"	"	M.	46	20 months.	Resection of lower fragment.
393	"	"	"	"	M.	68	11 weeks.	Friction of ends by walking on crutches.
394	"	"	"	"	M.	55	9 weeks.	Forcible friction of ends, once daily, for ten days.
395	"	Junction of upper and middle thirds.	"	"	M.	28	3 months.	Splints and tonic treatment.
396	"	"	"	"	M.	28	6 months.	H. H. Smith's apparatus, allowing patient to walk about, and retaining fracture almost immovable.
397	"	"	"	"	M.	50	31 weeks.	Resection of ends, drilling, and united by wire.
398	"	"	"	"	M	66	10 weeks.	Walking about on crutches, and starch bandage.
399	"	"	"	"	M.	36	5 months.	Drilling the ends, once only.
400	"	Junction of middle and upper thirds.	"	"	M.	40	12 months.	Resection of both ends.
401	"	"	"	"	M.	35	8 years.	Drilling ends, and drill left in.
402	"	Middle third.	"	"	M.	55	4 months.	Seton, between ends.
403	"	"	Simple.	Oblique.	M.	44	3 months.	" " "
404	"	"	2½ inches shortening.	Not stated.	M.	60	18 months.	One ivory peg in upper and two in lower fragment, driven in. Removal of a large piece of interposed muscle; drilling, and union by means of a twisted silver wire.
405	"	"	Not stated.	"	M.	42	2 years.	Resection of both ends of bone.
406	"	"	"	"	M.	Ad.	4 months.	Immovable dressing.
407	"	"	"	Oblique.	F.	30	6 months.	Malgaigne's spikes.
408	"	"	"	"	M.	26	5 months.	Forcible friction of ends, electricity, and starch bandage.
409	"	"	"	"	M.	26	9 months.	Seton, between ends, and rest.
410	"	Middle.	"	Not stated.	M.	22	7½ mos.	Forcible friction of ends daily.
411	"	"	"	"	M.	22	8 months.	Galvanism, daily, for three weeks, and ptyalism.
412	"	"	"	"	M.	22	13 months.	Drilling ends, and pegs driven in.
413	"	"	"	"	M.	36	Several months.	Scraping ends; gum, and chalk bandage.
414	"	"	Comminuted.	"	M.	29	9 years.	Resection of three-quarters of an inch of bone.
415	"	"	Not stated.	"	M.	Ad.	2½ years.	Ivory pegs driven in.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
382	Cut down.	Erysipelas and amputation.	....	14 weeks.	Failed.	Stanley.	Starch bandage and immovable dressing.	London Lancet, April and Nov. 1854.
383	Subcutan.	Inflammation.	2 weeks.	8 weeks.	Cured.	Rynd.	Not stated.	Dublin Jour. Med. Sci., vol. iv., 1847.
384	Cut down.	Shock.	....	30 hours.	Died.	C. P. Johnson.	Not stated.	Virginia Stethoscope, May, 1851.
385	....	Not stated.	....	8 weeks.	Cured.	E. Michener.	"	Amer. Jour. Med. Sci., Jan. 1848.
386	....	"	6 weeks.	6 weeks.	"	R. J. Levis.	"	Amer. Jour. Med. Sci., Jan. 1855.
387	Subcutan.	Abscess.	9 weeks.	10 mos.	"	Not stated.	"	New York Medical Times, Oct. 1851.
388	Cut down.	Not stated.	....	15 weeks.	"	J. M. Buzzell.	"	Boston Medical and Surg. Jour., Feb. 27, 1850.
389	Subcutan.	"Wound unhealthy for nine months."	....	4 months.	"	E. S. Cooper.	"	Cincinnati Lancet and Observer, July, 1859.
390	....	"Great constitutional disturbance."	....	7 weeks.	"	G. V. Dorsey.	"	N. Y. Amer. Med. Monthly, April, 1854.
391	....	Shortening.	....	4 months.	"	G. S. Wentz.	"	Correspondence with D. Hayes Agnew.
392	Cut down.	Not stated.	....	8 months.	Relieved.	B. Langenbeck.	"	B. Langenbeck's Clinic. (Gurlt's Surgery.)
393	....	"	....	2 months.	Cured.	E. Home.	"	Trans. Soc. Improv. Med. and Surg. Knowledge, vol. i., 1793.
394	....	....	....	6 weeks.	Failed.	V. Mott.	"	Trans. New York Acad. Med., vol. i., 1847–59.
395	....	Not stated.	....	8 weeks.	"	G. Dock.	"	Amer. Jour. Med. Sci., Jan. 1855.
396	....	Suppuration	9 weeks.	9 weeks.	Cured.	H. H. Smith.	"	Amer. Jour. Med. Sci., Jan. 1855.
397	Cut down.	Not stated.	....	15 weeks.	"	W. F. Peck.	"	Philadelphia Medical and Surgical Reporter, Oct. 2, 1869.
398	....	"	....	5 months.	"	Stanley.	"	London Medical Gazette, 1844–45.
399	Subcutan.	"	....	6 weeks.	"	D. Brainard.	"	Chicago Medical Journal, Sept. 1858.
400	Cut down.	Amputation.	....	10 weeks.	Died.	Gay.	"	Lond. Lancet, vol. ii., 1850.
401	Subcutan.	Not stated.	3 weeks.	8 weeks.	Cured.	D. H. Agnew.	"	Records of Surgical Wards in Penna. Hospital.
402	"	Profuse suppuration.	Not stated	3 months.	"	V. Mott.	Friction.	Trans. New York Acad. Med., vol. i., 1847–59.
403	"	Not stated.	7 weeks.	2 months.	"	"	Not stated.	Trans. New York Acad. Med., vol. i., 1847–59.
404	Cut down.	Amputation.	1 week.	14 weeks.	Failed.	Erichsen.	Blistering.	London Med. Times and Gazette, vol. xi., 1855.
405	"	Not stated.	....	24 days.	Died.	W. Ferguson.	Not stated.	London Lancet, vol. ii., 1850.
406	....	"	....	5 weeks.	Cured.	D. Wooster.	"	Pacific Medical and Surg. Journal, 1863.
407	Subcutan.	"	2 months.	3 months.	"	D. Prince.	"	St. Louis Med. and Surg. Journal, Oct. 1866.
408	....	"	....	6 weeks.	Failed.	C. A. Pope.	"	St. Louis Med. and Surg. Journal, Oct. 1866.
409	Subcutan.	Refractured limb in 9th month.	16 weeks.	13 mos.	Cured.	"	"	St. Louis Med. and Surg. Journal, Oct. 1866.
410	....	Not stated.	....	2 weeks.	Failed.	W. J. Square.	"	London Med. Times, vol. ii., N. S., 1851.
411	Subcutan.	"	....	4 months.	"	"	Friction.	London Med. Times, vol. ii., N. S., 1851.
412	"	"	3 weeks.	2 months.	"	"	Friction, galvanism.	London Med. Times, vol. ii., N. S., 1851.
413	Cut down.	"	....	14 days.	Died.	Not stated.	Not stated.	London Med. Times, vol. xiii., N. S., 1856.
414	"	"	....	Some wks	Cured.	G. M. Jones.	"	London Med. Times, vol. xiv., N. S., 1857.
415	Subcutan.	Amputation.	18 days.	4 weeks.	Failed.	Mackenzie.	"	Lond. Association Medical Journal, Feb. 10, 1854.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
416	Femur.	Middle.	Not stated.	Oblique.	M.	63	16 months.	H. H. Smith's apparatus, retaining fracture almost immovable, but allowing patient to walk about.
417	"	"	"	Not stated.	M.	45	9 weeks.	Desault's apparatus and rest.
418	"	"	Compound.	"	F.	33	8 months.	Pressure and rest.
419	"	"	Compound.	Not stated.	F.	33	12 months.	Seton, between ends.
420	"	"	Comminuted.	"	M.	27	22 weeks.	Extension by weights.
421	"	"	"	"	M.	27	26 weeks.	Immovable dressing of starch bandage.
422	"	"	"	"	M.	27	9½ mos.	Seton, between ends of bone.
423	"	"	"	"	M.	28	15 months.	Drilling in several places.
424	"	"	"	"	M.	28	16½ mos.	" " "
425	"	"	"	"	M.	28	20 months.	Periosteum turned up for an inch from each end; ends resected, drilled, and wired together.
426	"	"	Not stated.	Oblique.	M.	34	3 months.	Forcible friction of ends together.
427	"	"	"	"	M.	34	12 months.	Resection of both ends, and united by loop of wire twisted around ends.
428	"	"	3½ inches shortening.	"	M.	26	4 months.	Tenotomy of sartorius and fascia lata, extension, and Middledorps' swinging apparatus.
429	"	"	Not stated.	"	M.	38	3 months.	Swinging apparatus of Middledorps.
430	"	"	"	Not stated.	F.	32	4 months.	Compression of fragments by strong leathern splint; immovable dressing of flour and egg; walking on crutches.
431	"	"	2 inches shortening.	"	M.	48	6 months.	Friction of ends; paste bandage; and in third month walking about with leg immovable.
432	"	"	Compound.	"	M.	35	5 weeks.	Compression in tin splint.
433	"	"	Not stated.	"	M.	Ad.	5 months.	Friction by walking about on crutches.
434	"	"	"	"	M.	28	20 weeks.	Breaking up interposed mass, and extension apparatus.
435	"	"	"	"	M.	29	7 months.	Breaking up interposed mass, and in eight days plaster-of-Paris bandage.
436	"	"	"	"	M.	43	7½ mos.	Two ivory pegs driven into upper fragment, and one in lower.
437	"	"	"	"	M.	24	10 months.	Resection of upper fragment, scraping of lower, drilling each, and union by gold thread.
438	"	"	"	Oblique.	M.	26	3 months.	Pressure and rest.
439	"	"	"	"	M.	26	5 months.	Forcible friction of ends, and starch bandage.
440	"	"	"	"	M.	33	7 months.	Splint from pelvis to foot.
441	"	"	"	"	M.	60	5 weeks.	Firm pressure by Winchester's apparatus.
442	"	"	"	"	F.	25	17 weeks.	Starch bandage, and walking on crutches.
443	"	"	"	"	F.	25	6 months.	Acupuncture and electricity, three times weekly, and double inclined plane.
444	"	"	"	"	M.	Ad.	6 months.	Starch bandage, and walking about on crutches.
445	"	"	"	"	M.	Ad.	9 weeks.	Apparatus of Dr. Samuel Lilly,—invented and made in spring of 1854,—consisting of a steel splint from foot, on each side, to about four inches above fracture on inner side, and to pelvis on outer side; a pad in front of fracture, and joints at knee and ankle; leathern straps around limb, and one around pelvis. Patient allowed to walk about with foot on ground. The same as that known as H. H. Smith's apparatus.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Failed.	Surgeon.	Previous Treatment.	Work quoted from.
416	....	"Walks about without much inconvenience."	....	Not stated	Relieved.	H. H. Smith.	Not stated.	Amer. Jour. Med. Sci., Jan. 1851.
417	....	Not stated.	....	2 weeks.	Cured.	G. W. Norris.	"	Amer. Jour. Med. Sci., Jan. 1843.
418	....	"	....	3 months.	Failed.	"	"	Norris, Contributions to Practical Surgery, 1873.
419	Subcutan.	Amputation	3 months.	3 months.	Failed.	G. W. Norris.	Pressure and rest.	Norris, Contributions to Pract. Surg., 1873.
420	....	Not stated.	....	4 weeks.	"	Not stated.	Not stated.	Boston Med. and Surgical Jour., May 16, 1867.
421	....	"	....	3 months.	"	"	Extension.	Boston Med. and Surgical Jour., May 16, 1867.
422	Subcutan.	Profuse suppuration.	3 weeks.	6 months.	"	H. J. Bigelow.	Extension, immov'ble dressing.	Boston Med. and Surgical Jour., May 16, 1867.
423	"	Not stated.	....	6½ wks.	"	"	Extension, immov'ble dressing, seton.	Boston Med. and Surgical Jour., May 16, 1867.
424	"	"	....	16 weeks.	"	"	Extension, immov'ble dressing, seton, drilling.	Boston Med. and Surgical Jour., May 16, 1867.
425	Cut down.	Healthy suppurat'n.	5½ mos.	8 months.	Cured.	"	"	Boston Med. and Surgical Jour., May 16, 1867.
426	....	Not stated.	....	7 weeks.	Failed.	Not stated.	Not stated.	New West. Med. and Surg. Jour., Sept. 1848.
427	Cut down.	Abscess.	23 days.	4 months.	Cured.	D. Brainard.	Friction.	New West. Med. and Surg. Jour., August, 1848.
428	Subcutan.	Not stated.	....	8 weeks.	"	Paul and Klose.	Not stated.	Zeitschrift Klin. Med., Jahrg. 2, 1851. (Gurlt's Surgery.)
429	....	"	....	3 weeks.	"	" "	"	Conservative Chirurgie. (Gurlt's Surgery.)
430	....	"	....	6 weeks.	"	Stanley.	"	London Med. Gazette, vol. i., 1844–45.
431	....	"	....	5 months.	"	Limauge.	"	Presse Méd. Belge, April 27, 1851. (Gurlt's Surgery.)
432	....	"	....	6 weeks.	"	Brown.	"	Edinburgh Med. and Surg. Jour., vol. i., 1805.
433	....	"	....	3 months.	"	Lisfranc.	"	Précis de Méd. Opérat., t. ii., 1846.
434	....	"	....	17 weeks.	"	Von Bruns.	"	Deutsche Klinik, 1861, Beob. 17.
435	....	"	....	9 weeks.	"	"	"	Deutsche Klinik, 1861, B. 18.
436	Subcutan.	Not much inflammation.	3 days.	4½ mos.	Failed.	"	"	Deutsche Klinik, 1861, B. 26.
437	Cut down.	Not stated.	9 weeks.	5 months.	Cured.	Wutzer.	"	Weber, in Chir. Erfahr. u. Untersuch. (Gurlt's Surgery.)
438	....	"	....	6 weeks.	Failed.	Not stated.	"	St. Louis Med. and Surg. Jour., July, 1845.
439	....	"	....	"	"	C. A. Pope.	Pressure.	St. Louis Med. and Surg. Jour., July, 1845.
440	....	"	....	5 weeks.	Cured.	R. W. Smith.	Not stated.	London Med. Circular, March 1, 1854.
441	....	"	....	"	"	Coulson.	"	London Lancet, October, 1854.
442	....	"	....	9 weeks.	Failed.	F. D. Lente.	"	New York Journal Med., vol. v., Nov. 1850.
443	Subcutan.	"	....	"	Cured.	"	Starch bandage.	New York Journal Med., vol. v., Nov. 1850.
444	....	"	....	3 months.	"	J. Crosby.	Not stated.	Trans. New Hampshire Med. Soc., 1857.
445	....	"	....	4 weeks.	"	Samuel Lilly.	Splints.	Per letter to D. H. Agnew.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
446	Femur.	Middle.	Not stated.	Not stated.	M.	36	Not stated.	Drilling ends of overlapping bone, and a director, from pocket-case, put in and left remain.
447	"	"	Compound.	Oblique.	M.	35	5 months.	Drilling ends, and repeated eleven times, at intervals of fourteen and twenty-one days.
448	"	"	Not stated.	Not stated.	M.	29	5 weeks.	Perfect rest and tonic treatment.
449	"	Junction of middle and lower thirds.	"	"	M.	53	3 months.	Starch bandage.
450	"	"	"	"	M.	53	4 months.	Acupuncture by eight needles for four days, and by twelve for five days.
451	"	"	"	"	M.	53	5½ months.	Injected six drops and afterwards twenty drops liq. ammon. one part, aq. destillat. two parts.
452	"	"	"	"	M.	Ad.	5 months.	Injected gtt x of solution of ammonia (in proportion of one to three); four weeks later gtt. xx again; in a week another of gtt. xx of equal parts of ammonia and water. In the next five weeks four injections were made of compound tincture of iodine. The leg lay in a water glass splint. Phosphate of calcium was given internally.
453	"	"	"	Oblique.	M.	55	8 weeks.	Forcible friction of ends, and electricity.
454	"	"	"	"	M.	55	7½ months.	Drilling ends, and repeated three times, at intervals of seven or eight days.
455	"	"	"	Not stated.	M.	Ad.	Several months.	Immovable apparatus of starch bandage.
456	"	"	"	"	M.	Ad.	9 weeks.	Resection of ends of bone.
457	"	"	"	"	M.	6	2 years.	Drilling ends, and pegs driven in.
458	"	"	"	"	M.	1½	11 weeks.	Forcible breaking up of interposed mass.
459	"	Lower third.	"	"	M.	40	8 weeks.	Forcible friction of ends, and walking on crutches.
460	"	"	"	"	M.	40	5 months.	H. H. Smith's apparatus, allowing patient to walk about, but retaining fracture almost immovable.
461	"	"	"	"	F.	Ad.	3 months.	Resection of both ends.
462	"	"	"	Oblique.	F.	51	4½ months.	Inclined plane, and extension by weights.
463	"	"	"	"	F.	51	9 months.	Resection of upper end, and two steel pegs driven in.
464	"	"	Compound, comminuted.	Not stated.	M.	30	3 years.	Resection of ends, drilling, and wired together.
465	"	"	Opened into knee-joint.	Oblique.	M.	29	11 weeks.	Drilled with gimlet into lower end of upper fragment, and drill left in.
466	"	"	Not stated.	Not stated.	M.	15	3 months.	Resection of upper end.
467	"	"	"	Transverse.	M.	59	8 weeks.	Immovable apparatus of Ballif, making firm compression.
468	"	Lower fourth.	"	Not stated.	M.	......	Not stated.	Acupuncture by needles between ends.
469	"	"	"	"	M.	60	3 months.	Resection of upper fragment, scraping lower; pegs driven in.
470	"	Condyles.	"	"	M.	27	2 years.	Forcible friction of ends and splints.
471	Patella.	Not stated.	Compound, comminuted.	"	M.	35	10 weeks.	Tincture of iodine locally and internally.
472	"	"	Not stated.	"	M.	Ad.	Months.	Divided ligamentum patellæ and recti femoris, three inches above patella.
473	"	Middle.	"	Transverse.	M.	36	4 months.	Pasteboard splints and collars of harness leather.
474	"	"	"	"	M.	24	9 weeks.	Seton at side of, but not between, ends.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time, wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
446	Cut down.	Not stated.	10 days.	3½ mos.	Cured.	D. Brainard.	Not stated.	New West. Med. and Surg. Jour., March, 1852.
447	Subcutan.	"	....	6½ mos.	"	"	"	Chicago Med. Jour., Sept. 1858.
448	....	"	....	11 weeks.	"	G. Buck.	"	Trans. New York Acad. Med., vol. i., 1847–57.
449	....	"	....	48 days.	Failed.	M. Bourguet.	Starch bandage.	Gazette des Hôpitaux, 1863.
450	Subcutan.	"	....	4 weeks.	"	"	Starch bandage.	Gazette des Hôpitaux, 1863.
451	"	"	....	15 weeks.	Cured.	"	Starch bandage, and acupuncture.	Gazette des Hôpitaux, 1863.
452	"	"Consolidation complete and callous very extensive."	....	6 months.	"	Bourget.	Not stated.	Allg. Med. Cent. Zeit., 39, 1874.
453	....	Not stated.	....	2 months.	Failed.	H. O. Hitchcock.	"	New York American Med. Times, Dec. 1, 1860.
454	Subcutan.	"	....	14 weeks.	Cured.	"	Friction, electricity	New York American Med. Times, Dec. 1, 1860.
455	....	"	....	10 weeks.	"	C. Brackett.	Resection of upper fragment.	New Western Med. and Surg. Jour., Dec. 1857.
456	Cut down.	Severe second hemorrhage.	....	Few days.	Died.	C. T. Parkes.	Not stated.	Chicago Med. Jour., June, 1871.
457	Subcutan.	Amputation	....	Not stated	Failed.	H. Coote.	"	Lond. Lancet, vol. i., 1862.
458	....	Not stated.	....	"	"	Von Bruns.	"	Deutsche Klinik, B. xix., 1861.
459	....	"	....	9 weeks.	"	H. H. Smith.	"	Amer. Jour. Med. Sci., Jan. 1855.
460	....	"	17 weeks.	17 weeks.	Cured.	"	Friction, blisters.	Amer. Jour. Med. Sci., Jan. 1855.
461	Cut down.	Enormous bed-sore.	....	3 weeks.	Died.	T. M. Markoe.	Not stated.	New York Jour. Med., May, 1859.
462	....	Not stated.	....	4 months.	Failed.	Butlin.	"	London Lancet, Feb. 14, 1874.
463	Cut down.	Amputation	Not stated	7 weeks.	"	"	Extension.	London Lancet, Feb. 14, 1874.
464	"	Not stated.	14 weeks.	8 months.	Cured.	E. S. Cooper.	Not stated.	Cincinnati Lancet and Observer, July, 1859.
465	Subcutan.	Erysipelas, abscesses, exhaustion.	3 weeks.	47 days.	Died.	D. Hayes Agnew.	"	Records of Surg. Cases in Penna. Hospital.
466	....	Not stated.	....	3 months.	Cured.	Sick.	"	Med. Zeit. d. Vereins f. Heilk. Prakt., 1838, p. 259. (Gurlt's Surgery.)
467	....	"	....	4 weeks.	"	Dohlhoff.	"	Med. Zeit. d. Vereins f. Heilk. Prakt., p. 58, 1837. (Gurlt's Surgery.)
468	Subcutan.	"	....	Not stated	Failed.	Malgaigne.	Starch bandage.	Manuel Méd. Opér., 1849, p. 213.
469	Cut down.	"	1 year.	Long time	"	W. Ferguson.	Not stated.	Lond. Lancet, vol. ii., 1858, and vol. ii., 1859.
470	....	"	....	Not stated	"	J. Paget.	"	Lond. Med.-Chir. Trans., vol. li., 1868.
471	....	Joint was punctured to liberate pus, of which 12 oz. came away.	....	10 weeks.	Cured.	L. Levergood.	"	Amer. Jour. Med. Sci., Jan. 1860.
472	Subcutan.	Ossification going on.	....	4 months.	Relieved.	Dieffenbach.	"	Casper's Wochenschrift, Oct. 2, 1841.
473	....	Patient able to walk away.	....	Not stated	"	W. B. Dodson.	"	New Orleans Med. and Surg. Jour., Nov. 1867.
474	Subcutan.	"Union solid."	16 days.	8 weeks.	Cured.	F. Rynd.	"	Dublin Jour. Med. Sci., vol. iv., 1847.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
475	Patella.	Middle.	Not stated.	Transverse.	M.	30	9 weeks.	Drilling ends, and union by silver wire.
476	"	"	Compound.	Not stated.	M.	Ad.	5 months.	Hollow splint, adhesive plaster, and mechanical support.
477	Tibia and fibula.	Not stated.	Not stated.	"	M.	Ad.	7 months.	Resection of several inches of thickness of bone, and actual cautery.
478	"	"	"	"	F.	V'y old.	8 weeks.	Galvanism of limb, twice daily, from knee down.
479	"	"	"	"	M.	26	13 months.	Scarification with strong needle of cartilaginous ends of fracture, and in two weeks the immovable apparatus.
480	"	"	"	"	M.	Ad.	3 months.	H. H. Smith's apparatus, retaining fracture almost immovable, but allowing patient to walk about.
481	"	"	"	"	M.	Ad.	13 months.	Galvanism daily for two weeks.
482	"	"	"	"	F.	35	10 months.	Drilling ends, and repeated in two weeks.
483	"	"	"	"	M.	Ad.	16 weeks.	Copper half-boot attached to foot, and moving about on crutches.
484	"	"	Compound.	"	M.	40	5 months.	Periosteum turned up, ends of fracture resected, drilled into medullary cavity only, and wired together.
485	"	"	Not stated.	"	F.	60	2 months.	Starch bandage.
486	"	"	"	"	M.	22	7 months.	Resection of ends and wiring together.
487	"	"	"	"	M.	42	3 months.	M. Seutin's immovable apparatus.
488	"	"	"	"	M.	42	5 months.	Seton around the ends of bone, but not between.
489	"	"	"	"	M.	42	10 weeks.	Forcible friction daily for three days.
490	"	"	"	"	M.	34	4 months.	Resection of both ends.
491	"	"	"	"	M.	28	6 months.	Compound tincture of iodine externally night and morning.
492	"	"	"	"	M.	Ad.	6 weeks.	Dextrine bandage, and ptyalism for syphilis.
493	"	"	"	"	M.	10	3 years.	Periosteum turned up, both ends diagonally resected.
494	"	"	Compound.	"	M.	28	2 years.	Scraping ends of bone.
495	"	"	Not stated.	"	M.	Ad.	Not stated.	Seton; tenotomy of contracted tendo Achillis.
496	"	"	"	"	M.	30	20 months.	Butter of antimony on the exposed bone.
497	"	"	Compound.	"	M.	Ad.	10 months.	Resection of both ends of tibia.
498	"	"	Not stated.	"	F.	4	2 years.	" " "
499	"	"	Compound, comminuted.	"	M.	22	19 months.	Seton, and scarification of ends.
500	"	"	Compound.	"	M.	39	2 months.	Ivory pegs driven in, one in each fragment, and one between ends.
501	"	"	"	"	M.	Ad.	23 weeks.	Forcible friction of ends for an hour.
502	"	"	"	"	M.	42	23 weeks.	Forcible friction of ends of bone together.
503	"	"	Not stated.	"	M.	Ad.	5 months.	Friction by walking about on crutches.
504	"	"	"	Oblique.	M.	30	8½ weeks.	Ballif's immovable apparatus making firm compression.
505	"	"	"	Not stated.	M.	Ad.	15 weeks.	Painting limb at fracture with tincture of iodine.
506	"	"	"	"	M.	Ad.	14 weeks.	Painting limb at fracture for eight days, when union began.
507	"	Junction of upper and middle thirds.	"	"	M.	45	20 weeks.	Forcible breaking up of fibrous mass, and gutta-percha splints.
508	"	Middle.	"	"	M.	4	4 years.	Resection, and union by gold thread.
509	"	"	"	"	M.	16	6 months.	Firm and continued pressure by dextrine bandage.
510	"	"	"	"	M.	16	8 months.	Two setons, one on each side of fracture, but not between ends.
511	"	"	"	Oblique.	M.	31	10 weeks.	Pressure, and walking about on crutches.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
475	Subcutan.	Not stated.	6 weeks.	4 months.	Cured.	T. M. Logan.	Not stated.	Pacific Med. and Surgical Jour., Dec. 1866.
476	....	Deep abscess as result of original injury.	....	5 weeks.	Relieved.	C. King.	"	Dublin Med. Press, Dec. 8, 1847.
477	Cut down.	Not stated.	....	Not stated	Cured.	Faivre.	"	Anc. Jour. Méd., tome lxviii. p. 210.
478	....	"	....	4 weeks.	"	D. McRuer.	"	Trans. Amer. Med. Assoc., vol. iii., 1850.
479	Subcutan.	"	....	8 weeks.	"	G. F. Sandford.	"	Trans. Amer. Med. Assoc., vol. iii., 1850.
480	....	"	....	9 months.	"	Not stated.	"	Amer. Jour. Med. Sci., Jan. 1851.
481	....	"	....	Not stated	"	Holl.	"	London Med. Times and Gaz., Nov. 12, 1853.
482	Subcutan.	"	....	Some wks	Relieved.	Enos.	"	New York Jour. Med., Nov. 1859.
483	....	"	....	"	Cured.	D. P. Smith.	"	New York Amer. Medical Times, July 28, 1860.
484	Cut down.	Erysipelas.	....	3 months.	"	Thorndike.	"	Boston Medical and Surg. Jour., June 11, 1868.
485	....	Not stated.	....	3½ mos.	"	Not stated.	"	New York Medical Times, Oct. 1858.
486	Cut down.	Shock and erysipelas.	....	2 weeks.	Died.	G. Buck.	"	New York Medical Times, Oct. 1851.
487	....	Not stated.	....	2 months.	Failed.	Jobert (de Lamballe).	"	Comptes-Rendus d. Séanc. Acad. Sciences, April 16, 1860.
488	Subcutan.	"	10 days.	6 weeks.	Cured.	"	Immovable dressing.	Comptes-Rendus d. Séanc. Acad. Sciences, April 16, 1860.
489	....	"	....	6 weeks.	"	Worthington.	Not stated.	Provincial Medical Jour., Oct. 29, 1842.
490	Cut down.	"	....	8 months.	"	E. H. Bennett.	"	Dublin Jour. Med. Sci., vol. liii.
491	....	"	....	3 weeks.	"	Blasius.	"	Medicin. Zeitung, No. 39, 1853.
492	....	"	....	3 months.	"	W. B. Page.	"	Lond. Med.-Chirur. Trans., vol. xxxi., 1848.
493	Cut down.	"	....	5½ mos.	"	A. W. Stocks.	"	Massachusetts Med. and Surg. Reporter, 1870.
494	Subcutan.	"	....	2 months.	"	Not stated.	"	St. Thomas's Hosp. Statis. Reports, 1864.
495	"	"	1 day.	Not stated	"	"	"	Rust's Magazine, B. lxvii., 1841. (Gurlt's Surgery.)
496	....	"	....	4 weeks.	"	F. Lehmann.	"	Von Graefe's Jour. de Chir., Bd. iii., 1822. (Gurlt's Sur.)
497	Cut down.	"	....	4 months.	"	Uhde.	Resection.	Deutsche Klinik, 1855, p. 211.
498	"	Union commencing on 40th day.	....	Not stated	Relieved.	Dupuytren.	Not stated.	Bérard on Causes which retard Consolidation of Fractures, p. 52.
499	"	....	1 week.	3½ mos.	Cured.	G. M. Jones.	"	London Med. Times, vol. xv., 1814.
500	Subcutan.	Moderate reaction.	6 days.	8 weeks.	"	Paul.	Tincture of iodine.	Conserv. Chirur., B. xcviii. p. 302. (Gurlt's Surg.)
501	....	Not stated.	....	5 weeks.	"	Basedow.	....	Von Graefe's Jour. de Chir., B. xvii., 1831. (Gurlt's Sur.)
502	....	"	....	5 weeks.	"	Wenzel.	....	Med. Zeitung d. Vereins f. Heilk., 1836. (Gurlt's Sur.)
503	....	"	....	2 months.	"	C. G. Günther.	....	Med. Zeitung d. Vereins f. Heilk., 1842. (Gurlt's Sur.)
504	....	"	....	4 weeks.	"	Dohlhoff.	Friction, blistering.	Med. Zeitung d. Vereins f. Heilk., 1837. (Gurlt's Sur.)
505	....	"	....	Few wks.	"	Blasius.	Not stated.	Med. Zeitung d. Vereins f. Heilk., 1847. (Gurlt's Sur.)
506	....	"	....	Not stated	"	"	"	Med. Zeitung d. Vereins f. Heilk., 1847. (Gurlt's Sur.)
507	....	"	....	10 weeks.	"	Von Bruns.	"	Deutsche Klinik, B. xxii., 1861.
508	Cut down.	"	7 days.	4 weeks.	"	Wutzer.	"	Dissert. Spicileg. cull. nonnull. Chirurg., 1849. (Gurlt's Surgery.)
509	....	"	....	2 months.	Failed.	W. B. Page.	"	Lond. Med.-Chirur. Trans., vol. xxxi., 1848.
510	Subcutan.	Inflammation.	10 days.	4½ mos.	Cured.	"	Pressure.	Lond. Med.-Chirur. Trans., vol. xxxi., 1848.
511	....	Not stated.	....	6 weeks.	Failed.	B. Brodie.	Not stated.	Brodie's Pathology and Surgery.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
512	Tibia and fibula.	Middle.	Simple.	Not stated.	M.	Ad.	8 weeks.	Three gutta-percha splints, and over this starch bandage; leg being dressed every fourteen days.
513	"	"	"	Oblique.	M.	22	11 weeks.	Side splints and firm bandaging.
514	"	"	Not stated.	Not stated.	M.	65	8 months.	Firm splints, recumbent position, and tonics.
515	"	"	Not stated.	Not stated.	M.	65	11 months.	Acupuncture by steel needles between ends.
516	"	"	"	"	M.	65	16 months.	Drilling ends, and two ivory pegs driven in.
517	"	"	"	"	M.	50	6 months.	Resection of both ends of tibia, and walking on crutches.
518	"	"	Compound.	"	F.	48	6 weeks.	Resection of both ends of tibia and fibula.
519	"	"	Not stated.	Transverse.	M.	22	3 months.	Splint, with leg flexed nearly to right angle with thigh.
520	"	"	Compound.	Not stated.	M.	51	"	Splint of unoiled sole-leather, and "tent" introduced.
521	"	"	Not stated.	Oblique.	M.	27	14 weeks.	Pasteboard splints, and starch bandage.
522	"	"	Simple.	Not stated.	M.	40	3 months.	Starch bandage.
523	"	"	"	"	M.	40	5½ months.	Electro-galvanism by acupuncture.
524	"	"	"	Transverse.	M.	35	3 years.	Drilling both ends, and some time afterwards forcible friction.
525	"	"	Not stated.	Not stated.	F.	28	6 weeks.	Splints and firm bandaging.
526	"	"	"	"	M.	Ad.	24 weeks.	Forcible friction, breaking up interposed mass, and plaster-of-Paris dressing.
527	"	"	"	"	F.	60	3 months.	Forcible friction of ends together.
528	"	"	"	Oblique.	M.	30	5½ months.	Driving in two ivory pegs into ends.
529	"	"	"	Not stated.	M.	40	18 weeks.	Resection of upper fragment.
530	"	Middle third.	"	Oblique.	M.	46	7 weeks.	Starch bandage, and walking on crutches.
531	"	"	Compound.	Not stated.	M.	28	3½ weeks.	Fracture-box.
532	"	"	Comminuted.	"	M.	19	2 months.	Phosphate of lime, gr. xv, three times daily, and splints.
533	"	"	Compound, comminuted.	"	M.	47	4 months.	Phosphate of lime, gr. xv, three times daily, and splints.
534	"	"	Not stated.	"	F.	41	10 weeks.	Tincture of iodine painted over seat of fracture.
535	"	"	"	"	F.	20	8 weeks.	Tincture of iodine painted over seat of fracture.
536	"	Junction of middle and lower thirds.	Compound, of right leg.	"	M.	22	11 weeks.	Very firmly bandaged, and swinging splint.
537	"	"	Simple, of left leg.	"	M.	22	11 weeks.	Side splints, and firm bandaging.
538	"	"	Compound.	"	M.	25	9 months.	Swinging splint, and dextrine bandage.
539	"	"	Not stated.	Oblique.	F.	30	16 weeks.	Forcible friction of ends, and extension.
540	"	"	"	"	F.	30	11 months.	Resection of lower fragment,—tibia,—shaving off upper, and caustic potash to ends.
541	"	"	"	"	F.	32	2 years.	Resection of both ends of tibia.
542	"	"	"	"	M.	20	11 weeks.	Resection of ends; forcible friction of ends afterwards, and starch bandage.
543	"	"	"	"	M.	Ad.	12 months.	Breaking up forcibly interposed mass, and Von Bruns's apparatus.
544	"	"	"	"	M.	14	2 years.	Resection of ends of tibia.
545	"	Lower third.	Born with fracture.	"	M.	4	4 years.	Resection of ends of bones.
546	"	"	Not stated.	"	F.	22	6 months.	Resection of upper fragment, and scraping of lower one.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
512	....	Not stated.	....	6 months.	Cured.	J. H. Houghton.	Not stated.	Provincial Med. and Surg. Jour., Oct. 1850.
513	....	"	....	5 months.	"	H. Lowndes.	"	Liverpool Med. and Surg. Reports, 1870.
514	....	"	....	3 months.	Failed.	J. Hilton.	"	London Lancet, Oct. 1852.
515	Subcutan.	"	Several days.	7 weeks.	"	"	Splints.	" " "
516	"	"	One, 6 weeks; other, 9 weeks.	5 months.	Cured.	"	Acupuncture.	" " "
517	Cut down.	"	....	3 months.	"	E. S. Cooper.	Not stated.	London Lancet, 1852.
518	"	"	....	2 months.	"	Gant.	"	London Lancet, vol. ii., 1862.
519	....	"	....	4 weeks.	"	J. Crosby.	"	Transac. New Hampshire Med. Society, 1857.
520	....	"	....	6 weeks.	"	W. J. Sneed.	"	Nashville Med. and Surg. Jour., Nov. 1855.
521	....	"	....	3 weeks.	"	G. K. Amerman.	"	Chicago Med. Jour., July, 1860.
522	....	"	....	10 weeks.	Failed.	J. Watson.	"	New York Medical Times, Oct. 1851.
523	Subcutan.	"	....	6 weeks.	Cured.	"	Starch bandage.	New York Medical Times, Oct. 1851.
524	"	"	....	10 weeks.	"	D. Prince.	Not stated.	Chicago Medical Examiner, 1863.
525	....	"	....	8 months.	"	R. H. Oswald.	"	Provincial Med. Journal, Sept. 3, 1842.
526	....	"	....	3 months.	Relieved.	Von Bruns.	"	Deutsche Klinik, B. xx., 1861.
527	....	"	....	"	Cured.	Sharkey.	"	Dublin Med. Press, April 9, 1845.
528	Subcutan.	"	One, 12 days; other, 22 days.	"	"	B. Langenbeck.	"	Deutsche Klinik, p. 207, 1852.
529	Cut down.	"	....	9 weeks.	"	Düsterberg.	"	Casper's Wochenschrift, p. 563, 1835.
530	....	"	....	2 months.	"	Stanley.	"	London Medical Gazette, 1844–45.
531	....	"	....	4 months.	"	G. W. Norris.	"	Amer. Jour. Med. Sci., 1843.
532	....	"	....	Not stated	"	B. Vallance.	Starch bandage.	Transac. Provin. Med. and Surg. Assoc., 1850.
533	....	"	....	2½ mos.	"	"	Not stated.	Transac. Provin. Med. and Surg. Assoc., 1850.
534	....	"	....	2 weeks.	"	Hodann.	"	Med. Zeitung d. Vereins f. Heilk. Prakt., 1847. (Gurlt's Surgery.)
535	....	Paralysis of right side.	....	3 weeks.	"	"	"	Günsburg's Zeitsch. Klin. Med., 1850. (Gurlt's Surgery.)
536	....	Suppurat'n.	....	5½ mos.	"	H. Lowndes.	"	Liverpool Med. and Surg. Reports, 1870.
537	....	Not stated.	....	5 months.	"	"	"	Liverpool Med. and Surg. Reports, 1870.
538	....	"	....	3 months.	"	W. B. Page.	Leathern splint.	London Medico-Chirurg. Trans., vol. xxxi., 1848.
539	....	"	....	7 months.	Failed.	H. H. Smith.	Not stated.	Amer. Jour. Med. Sci., Jan. 1848.
540	Cut down.	"Great uterine disturbance."	....	5 months.	"	"	Friction and extension.	Amer. Jour. Med. Sci., Jan. 1848.
541	"	"Great uterine disturbance, and erysipelas.	....	7 months.	"	"	Friction, extension, and resection.	Amer. Jour. Med. Sci., Jan. 1848.
542	"	Not stated.	....	Few wks.	Cured.	E. Warren.	Not stated.	Baltimore Med. Jour. and Bulletin, Sept. 1871.
543	....	"	....	6 months.	"	Von Bruns.	"	Deutsche Klinik, B. xxiv., 1861.
544	Cut down.	"	....	3 months.	"	Jordan.	"	Trait. des Pseudarth., 1860, p. 18.
545	"	No reaction.	....	6 months.	Failed.	Curling.	"	London Med. Times and Gaz., N. S., vol. xi. pp. 189 and 544, 1855.
546	"	....	....	8 weeks.	Cured.	Stettner & Prautl.	"	Oester. Medic. Wochenschrift, 1847. (Gurlt's Surgery.)

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
547	Tibia and fibula.	Lower third.	Intra-uterine.	Oblique.	F.	1	More than 1 year.	One seton passed between both bones.
548	"	"	Compound.	"	M.	28	4 months.	Drilling tibia, and repeated in three weeks.
549	"	"	Not stated.	"	M.	25	2 years.	Bandaged firmly, and allowed to walk about.
550	"	"	"	"	M.	25	26 months.	Drilling ends, and starch bandage in fourth week.
551	"	"	Simple.	"	M.	Ad.	10 weeks.	Seutin's immovable apparatus.
552	"	"	"	"	M.	Ad.	4½ months.	Apparatus of H. H. Smith, which retains fracture almost immovable, but allows patient to walk about.
553	"	"	Not stated.	Not stated.	F.	24	2½ months.	Silk seton around ends, but not between them.
554	"	"	"	"	M.	40	18 weeks.	Tincture of iodine locally, over seat of fracture.
555	"	"	"	"	M.	40	10 weeks.	Tincture of iodine locally, over seat of fracture.
556	"	"	"	"	M.	38	6½ months.	Forcible friction of ends daily.
557	"	"	"	"	M.	28	6 months.	Tincture of iodine over seat of fracture.
558	"	"	"	"	M.	61	20 weeks.	Forcible breaking up of interposed mass, and Von Bruns's iron apparatus.
559	"	"	"	"	M.	Ad.	3 months.	Resection of both ends of tibia.
560	"	"	"	"	M.	24	2 years.	Blisters to seat of fracture.
561	"	"	"	"	M.	24	28 months.	Drilling ends, and ivory pegs driven in.
562	"	"	"	"	M.	13	12½ years.	Resection of both ends of bone.
563	"	"	"	"	M.	13½	13 years.	Drilling ends, and ivory pegs driven in.
564	"	"	Heel drawn up.	"	M.	30	2 years.	Tendo Achillis divided; tincture of iodine locally, daily for four weeks, and then two or three time weekly for three mouths.
565	"	"	Not stated.	Oblique.	M.	33	4 years.	Drilling ends, and starch bandage.
566	"	"	"	Very oblique.	M.	23	9 weeks.	Successive blistering for five weeks.
567	"	"	Compound.	Not stated.	M.	48	2 months.	Galvanism locally, and stimulating embrocations.
568	"	"	Simple.	Oblique.	M.	Ad.	Some mos.	Drilling callus only.
569	"	"	Not stated.	Not stated.	M.	22	4 weeks.	Pressure and pasteboard splints.
570	"	"	Simple.	Transverse.	M.	35	14 weeks.	Galvanism by acupuncture, daily for thirteen days; pressure, and walking about with firm apparatus.
571	Tibia.	Not stated.	Compound.	Not stated.	M.	Ad.	2½ months.	Resection of ends of fragments.
572	"	"	Not stated.	"	M.	Ad.	Not stated.	Seton.
573	"	"	Compound.	"	M.	45	5 months.	Drilling ends once, and immovable apparatus for three weeks.
574	"	"	Not stated.	"	M.	38	3 years.	Scarification with strong needle of each end, and immovable apparatus.
575	"	"	"	"	M.	......	12 months.	Forcible breaking up of interposed mass by extension.
576	"	"	"	"	M.	Ad.	Not stated.	Seton, compression, and rest.
577	"	"	"	"	M.	Ad.	"	Seton.
578	"	"	"	"	M.	Ad.	"	"
579	"	"	Compound.	"	M.	30	9 months.	Application to ends of caustic potash for a minute.
580	"	"	Not stated.	"	M.	Ad.	16 weeks.	Resection of upper fragment.
581	"	"	"	Oblique.	M.	32	Not stated.	Scraping ends, drilling them, and wiring with silver wire.
582	"	"	"	Not stated.	M.	45	22 weeks.	Immovable paste dressing; and friction by walking occasionally on leg.
583	"	"	"	"	M.	58	10 weeks.	Acupuncture by six needles between ends.
584	"	"	"	"	M.	6	3 years.	Acupuncture by one needle between ends.
585	"	"	"	"	F.	42	20 months.	Butter of antimony on the exposed bone.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
547	Subcutan.	"Violent inflammat'n in fourth week."	4 weeks.	4 weeks.	Failed.	V. Mott.	Not stated.	Transac. New York Acad. Med., vol. i., 1847-57.
548	"	Not stated.	....	6 weeks.	Cured.	R. D. Mussey.	"	Trans. Amer. Med. Assoc., vol. vii., 1854.
549	....	"	....	5 weeks.	Failed.	H. M. Fisher.	"	New York Medical Press, Oct. 8, 1859.
550	Subcutan.	"	....	2½ mos.	Cured.	"	Splints.	New York Medical Press, Oct. 8, 1859.
551	....	"	....	2 months.	Failed.	W. Waters.	Not stated.	Amer. Jour. Med. Sci., Jan. 1855.
552	....	"	5 months.	5 months.	Cured.	"	Immovable apparatus.	Amer. Jour. Med. Sci., Jan. 1855.
553	Subcutan.	"	4 weeks.	5½ weeks	"	F. Rynd.	Friction.	Dublin Jour. Med. Sci., vol. iv., 1847.
554	....	"	....	Not stated	"	Hodann.	Not stated.	Günsburg's Zeitschr. Klin. Med., 1850. (Gurlt's Surgery.)
555	....	"	....	8 days.	"	"	"	Günsburg's Zeitschr. Klin. Med., 1850. (Gurlt's Surgery.)
556	....	"	....	Not stated	Failed.	Lange.	Tincture of iodine.	Günsburg's Zeitschr. Klin. Med., 1852. (Gurlt's Surgery.)
557	....	"	....	3 weeks.	Cured.	Höpstein.	Not stated.	Med. Zeitung d. Vereins f. Heilk. Prakt., 1851. (Gurlt's Surgery.)
558	....	"	....	6 weeks.	"	Von Bruns.	"	Deutsche Klinik, B. xxii., 1861.
559	Cut down.	Amputation.	....	6 days.	Failed.	J. F. Heyfelder.	"	Deutsche Klinik, p. 397, 1856.
560	....	Not stated.	....	4 weeks.	"	Stanley.	"	Lond. Lancet, vol. ii., 1851.
561	Cut down.	"	2 months.	4 months.	Cured.	"	Blisters.	" " " "
562	"	"	....	3½ mos.	Failed.	Bowman.	Not stated.	London Lancet, Oct. 1852.
563	"	"	2 months.	4 months.	"	"	Resection.	" " " "
564	Subcutan.	"	....	6 months.	Cured.	Scott.	Not stated.	London Lancet, Sept. 16, 1843.
565	"	"	....	11 weeks.	"	M. W. Townsend.	"	Chicago Medical Journal, April, 1861.
566	....	"	....	9 weeks.	"	J. Watson.	"	New York Medical Times, Oct. 1851.
567	....	"	....	3 months.	"	"	"	New York Medical Times, Oct. 1851.
568	Subcutan.	"	....	Not stated	Failed.	D. Prince.	"	Chicago Med. Examiner, Dec. 1863.
569	....	"	....	6 weeks.	Cured.	G. W. Norris.	"	Amer. Jour. Med. Sci., Jan. 1843.
570	Subcutan.	"	....	4 weeks.	"	Burman.	"	Dublin Med. Press, Dec. 15, 1847.
571	Cut down.	"	....	5 weeks.	"	M. Josse.	"	Velpeau's Surgery.
572	Subcutan.	"	Some mos.	Some mos	Failed.	B. Brodie.	"	Brodie's Lectures on Pathology and Surgery.
573	"	"	....	4 weeks.	Cured.	H. Jewett.	Pressure and friction	Trans. Amer. Med. Assoc., vol. vii, 1854.
574	"	"	....	8 weeks.	"	G. K. Sandford.	Not stated.	Trans. Amer. Med. Assoc., vol. iii., 1850.
575	....	"	....	Not stated	Relieved.	Dixon.	"	Lond. Lancet, vol. ii. 1852.
576	Subcutan.	"Probably cured."	Not stated	"	"	Crompton.	"	Lond. Med. Gazette, N. S., vol. ii., 1850.
577	"	"	"	"	"	"	"	Lond. Med. Gazette, N. S., vol. ii., 1850.
578	"	"	"	"	"	"	"	Lond. Med. Gazette, N. S., vol. ii., 1850.
579	Cut down.	Not stated.	....	4 months.	Cured.	Cline, Jr.	"	Chelius's Surgery (South), vol. i., 1847.
580	"	"	....	5 weeks.	"	Düsterberg.	"	Casper's Wochenschrift, p. 563, 1835.
581	"	"	3 weeks.	Not stated	"	E. S. Cooper.	"	Pacific Med. and Surg. Reporter, April 19, 1862.
582	....	"	....	"	"	Lambrecht.	"	Med. Zeitung d. Vereins f. Heilk. Prakt., 1838. (Gurlt's Surgery.)
583	Subcutan.	Slight suppuration.	7 days.	4 weeks.	"	J. Paul.	"	Conservative Chirurg., B. xcv. (Gurlt's Surgery.)
584	"	Not stated.	Not stated	Not stated	Relieved.	C. Bell.	"	Roux, Relation d'un Voyage, etc. (Gurlt's Surg.)
585	....	"	....	3½ mos.	Cured.	Weilinger.	"	Rust's Magazine, Bd. xxxiv., 1831. (Gurlt's Surgery.)

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
586	Tibia.	Not stated.	Not stated.	Not stated.	F.	30	4 months.	Drilling ends, and two ivory pegs driven in.
587	"	"	"	"	F.	30	6 months.	Drilling through fragments, and drill left in.
588	"	"	"	"	F.	30	9½ months.	Drilling into ends of bone.
589	"	"	"	"	F.	30	11 months.	Resection of ends of bone, which seemed diseased.
590	"	"	"	"	F.	31	16 months.	Broke the fibula, which seemed to prevent ends of tibia coming together, and in two weeks used forcible friction of ends; also starch bandage.
591	"	"	Simple.	"	F.	28	5 months.	Drilling ends, and two ivory pegs driven in.
592	"	"	Not stated.	"	M.	29	10 months.	Fracture dressing.
593	"	"	"	"	M.	29	13 months.	Drilling both ends.
594	"	"	"	"	M.	29	16 months.	Trephining both ends of bone halfway through their thickness.
595	"	"	"	"	M.	Ad.	8 months.	Firm bandaging, splints, and walking on crutches.
596	"	"	"	"	M.	Ad.	3 weeks.	Resection of both ends, drilling, and wiring.
597	"	"	"	"	M.	4	12 months.	Resection of ends, and starch bandage.
598	"	"	"	Transverse.	M.	40	3½ months.	Electrical current through limb daily, and starch bandage.
599	"	"	"	Not stated.	M.	25	19 months.	Seton, between ends of bone.
600	"	"	"	"	M.	Ad.	13 months.	Electricity daily in length and across the limb.
601	"	"	"	"	M.	Ad.	Some mos.	Seton, between ends of bone.
602	"	"	"	"	M.	Ad.	4 months.	Drilling ends of bone once.
603	"	"	"	"	F.	9	Several mos.	Tenotomy, and drilling eight holes in end of bone.
604	"	"	"	"	F.	12	Not stated.	Drilling of ends.
605	"	"	"	"	F.	14	"	Resection of ends.
606	"	"	"	"	M.	Ad.	"	" "
607	"	Upper third.	Compound, comminuted.	Oblique.	M.	35	5 months.	Injection of argenti nitratis, and immovable apparatus.
608	"	"	"	"	M.	36	12 months.	Seton, between ends.
609	"	"	"	"	M.	36	14 months.	Acupuncture, with needles between ends.
610	"	"	"	"	M.	36	18 months.	Apparatus known as H. H. Smith's.—retaining fracture almost immovable, but allowing patient to walk about.
611	"	"	Not stated.	Not stated.	M.	30	3 months.	Drilling both ends, and repeated in two weeks.
612	"	Middle.	Simple.	Oblique.	M.	21	5 months.	Drilling ends, and two ivory pegs driven in.
613	"	Middle.	Compound.	Not stated.	F.	54	8 months.	Seton.
614	"	"	Transverse.	Oblique.	M.	45	10 weeks.	Walking about in H. H. Smith's apparatus.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
586	Subcutan.	Not stated.	9 days.	8 weeks.	Failed.	W. H. Pancoast.	Not stated.	Phila. Med. and Surg. Reporter, March 3, 1866.
587	"	Abscess.	8 days.	Several months.	"	"	Ivory pegs.	Phila. Med. and Surg. Reporter, March 3, 1866.
588	"	Not stated.	....	6 weeks.	"	"	Ivory pegs and drilling.	Phila. Med. and Surg. Reporter, March 3, 1866.
589	Cut down.	"The abundant callus was soon absorbed."	....	Some mos	"	"	Ivory pegs and drilling twice.	Phila. Med. and Surg. Reporter, March 3, 1866.
590	....	"Limb much firmer."	....	3½ mos.	Relieved.	"	Ivory pegs, drilling twice, and resection.	Phila. Med. and Surg. Reporter, March 3, 1866.
591	Subcutan.	"When discharged, there was considerable callus thrown out."	....	4 weeks.	"	D. H. Agnew.	Not stated.	Phila. Med. and Surg. Reporter, Feb. 14 and April 29, 1865.
592	....	Not stated.	....	3 months.	Failed.	Jackson.	"	London Med. Times and Gaz., vol. xiv., N. S., 1857.
593	Subcutan.	"	....	14 weeks.	Cured.	"	Drilling.	London Med. Times and Gaz., vol. xiv., N. S., 1857.
594	Cut down.	"	....	4 weeks.	Failed.	"	Splints.	London Med. Times and Gaz., vol. xiv., N. S., 1857.
595	....	"	....	4 months.	Cured.	D. P. Smith.	Not stated.	New York American Med. Times, July 21, 1860.
596	Cut down.	"	6 months.	8 months.	"	M. Lettenneur.	"	Gazette Hebdomadaire, No. 2, 1871.
597	"	"	....	5 months.	"	W. G. Williams.	"	Western Med. and Surg. Jour., Jan. 1852.
598	....	"	....	7 weeks.	"	J. Watson.	"	New York Medical Times, Oct. 1851.
599	Subcutan.	Erysipelas.	9 weeks.	3½ mos.	"	Not stated.	"	New York Medical Times, Oct. 1851.
600	....	Not stated.	....	6 weeks.	"	Birch.	"	Stevens's translations of Boyer.
601	Subcutan.	"Result all that could be expected."	2 weeks.	Not stated	Relieved.	D. Prince.	"	Chicago Med. Times, Dec. 1863.
602	"	Not stated.	....	2 weeks.	Cured.	D. Brainard.	"	Chicago Med. Jour., Sept. 1858.
603	"	"	....	3 months.	"	Dieffenbach.	"	Casper's Wochenschrift, p. 730, 1846.
604	"	"	....	6 months.	Failed.	"	"	Casper's Wochenschrift, p. 730, 1846.
605	Cut down.	"	....	Not stated	Cured.	Von Textor.	"	Wiederzeugung d. Knoch. u. Resect., 1842. (Gurlt's Surgery.)
606	"	"	....	"	"	Ant. Dubois.	"	Foussard, Diss. sur les Fractures. (Gurlt's Surg.)
607	"	"	....	6 months.	Failed.	W. Waters.	"	Amer. Jour. Med. Sci., Jan. 1855.
608	"	"	4 weeks.	8 weeks.	"	"	Injection of argenti nitratis.	Amer. Jour. Med. Sci., Jan. 1855.
609	"	"	....	8 weeks.	"	"	Injection of argenti nitratis, and seton.	Amer. Jour. Med. Sci., Jan. 1855.
610	....	"	6 months.	6 months.	Cured.	"	Injection of argenti nitratis, seton, and acupuncture.	Amer. Jour. Med. Sci., Jan. 1855.
611	Subcutan.	"	....	10 weeks.	"	H. Jewett.	Not stated.	Buffalo Medical Journal, May, 1853.
612	Subcutan.	"When discharged, patient had considerable union of fragments."	One, 2 weeks; other, 4 weeks.	5 weeks.	Relieved.	S. D. Gross.	"	Phila. Med. and Surg. Reporter, Oct. 14, 1865.
613	Subcutan.	Not stated.	10 days.	10 weeks.	Cured.	Saurer.	"	Oppenheim, in Rust's Magaz., B. xxvii., 1828. (Gurlt's Surgery.)
614	....	Not stated.	....	3 months.	"	W. Waters.	"	Phila. Med. and Surg. Reporter, March 9, 1861.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
615	Tibia.	Middle.	Comminuted.	Not stated.	M.	27	4 months.	Scraping ends, drilling, and wiring together.
616	"	"	Compound.	Oblique.	M.	29	14 weeks.	Resection of ends.
617	"	"	"	"	M.	29	9 months.	Forcible friction of ends, leathern splints or apparatus, and walking on limb.
618	"	"	Simple.	Not stated.	M.	21	7 months.	Drilling ends, and repeated twice at intervals of eight or nine days.
619	"	"	Compound, comminuted.	"	M.	31	8 months.	Firm bandaging, pasteboard splints, and walking on crutches.
620	"	"	Not stated.	Transverse.	M.	45	15 weeks.	Drilling diagonally through both ends, and drill left in.
621	"	"	"	Not stated.	M.	48	8 weeks.	Drilling with gimlet screw, and this allowed to remain.
622	"	"	"	"	M.	45	15 weeks.	Drilling with gimlet screw, and this allowed to remain.
623	"	"	"	"	M.	50	16 weeks.	Forcible friction of interposed mass, and Von Bruns's apparatus.
624	"	"	"	"	M.	26	8 weeks.	Drilling ends with two drills, and these left in.
625	"	"	"	"	M.	40	13 weeks.	Starch bandage, and walking about.
626	"	Middle third.	Compound.	Oblique.	M.	43	3 months.	Amesbury's apparatus.
627	"	"	"	"	M.	43	5 months.	Locally, twice daily, tincture of iodine one part, lime-water two parts.
628	"	"	"	"	M.	4	15 months.	Scraping ends with tenotomy knife; firm pressure.
629	"	"	"	Not stated.	M.	Ad.	3½ mos.	Friction of ends; electricity by acupuncture every other day, and starch bandage.
630	"	"	"	"	M.	Ad.	5 months.	Drilling ends of bone at intervals; walking about on crutches, false joint being kept immovable.
631	"	"	Compound, comminuted.	"	M.	22	7 months.	Resection of both ends of bone.
632	"	"	Not stated.	"	M.	Ad.	Not stated.	Seton, and immovable dressing of plaster of Paris.
633	"	Junction of middle and lower thirds.	"	Oblique.	M.	30	2 months.	Drilling ends, and ivory pegs driven in.
634	"	"	"	"	M.	30	5 months.	Treated for secondary syphilis.
635	"	"	"	Transverse.	M.	32	6½ wks.	Electricity by acupuncture every other day; immovable apparatus.
636	"	"	"	Oblique.	M.	45	5 weeks.	Modification of Malgaigne's spikes, an ivory being used for iron one.
637	"	"	"	"	M.	58	3 weeks.	Resection of both ends, drilling, and united by copper wire.
638	"	"	"	Not stated.	M.	22	6 weeks.	Tincture of iodine locally, and Fricke's suspensory apparatus occasionally.
639	"	Lower third.	"	"	M.	Boy	2 years.	Seton, between ends.
640	"	"	"	"	M.	Ad.	8 months.	Drilled ends, and left drill in.
641	"	"	Ends overlapped 2 inches.	"	F.	9	8 years.	Forcible extension.
642	"	"	"	"	F.	11	10 years.	"Splints, etc."
643	"	"	"	"	F.	25	"24 years."	Divided tendo Achillis; forcible extension was made, and pressure above fracture in front, and counter-pressure above ankle behind.
644	"	"	Comminuted.	"	M.	Ad.	3 months.	Forcible friction of ends, and splints.
645	"	"	Not stated.	"	F.	35	10 weeks.	Electricity by acupuncture every other day, and immovable apparatus.
646	"	"	"	"	M.	Boy	18 months.	Drilling ends, and firm splints.

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
615	Cut down.	Not stated.	3 months.	8 months.	Cured.	E. S. Cooper.	Not stated.	New York American Medical Times, Aug. 1861.
616	"	"	....	7 months.	Failed.	A. G. Walter.	"	Cincinnati Western Jour. of Med., March, 1867.
617	....	"Union firm 12 months after using leathern apparatus."	....	12 mos.	Cured.	"	Resection.	Cincinnati Western Jour. of Med., March, 1867.
618	Subcutan.	Not stated.	....	4 weeks.	"	D. Brainard.	Not stated.	Chicago Medical Journal, Sept. 1858.
619	....	"	....	3½ mos.	"	E. Richardson.	"	Philadelphia Med. Times, Dec. 15, 1870.
620	Subcutan.	"No sloughing, nor ulceration."	30 days.	6 weeks.	"	D. H. Agnew.	"	Philadelphia Med. Times, Oct. 1, 1870.
621	"	Not stated.	2 weeks.	13½ wks.	"	"	Puncture and drill.	Records of Surgical Wards in Penna. Hospital.
622	"	"	30 days.	7 weeks.	"	"	Not stated.	Records of Surgical Wards in Penna. Hospital.
623	....	"	....	27 days.	"	Von Bruns.	Tincture of iodine.	Deutsche Klinik, B. xxiii., 1861.
624	Subcutan.	Small abscess.	One, 16 days; other, 17 days.	8 weeks.	"	Fletcher.	Not stated.	London Med.-Chir. Trans., vol. xlvii., 1864.
625	....	Not stated.	....	12 mos.	"	A. Küttlinger.	"	Medical Correspondence, 1850. (Gurlt's Surgery.)
626	....	"	....	2 months.	Failed.	W. Willoughby.	"	Trans. New York Medical Society, vol. ii.
627	....	"	....	8 weeks.	Cured.	"	Amesbury's apparatus.	Trans. New York Medical Society, vol. ii.
628	Subcutan.	"	....	3 months.	Failed.	Tapp.	Not stated.	London Med. Times, vol. xiii., N. S., 1836.
629	"	"	....	5 weeks.	"	F. D. Lente.	"	Virginia Med. and Surg. Jour., Aug. 1856.
630	"	"	....	9 months.	Cured.	"	Friction and electricity.	Virginia Med. and Surg. Jour., Aug. 1856.
631	Cut down.	"Much callus thrown out."	....	Not stated	Relieved.	W. Collis.	Not stated.	Dublin Journal of the Medical Sciences, vol. l.
632	Subcutan.	Not stated.	20 days.	"	Cured.	Serres.	"	Gaz. Méd. de Montpellier, 1847. (Gurlt's Surgery.)
633	"	Suppuration	19 days.	5 weeks.	Failed.	Barnes.	"	London Lancet, vol. ii., Nov. 1, 1873.
634	....	Not stated.	....	26 days.	Cured.	"	Ivory pegs.	London Lancet, vol. ii., Nov. 1, 1873.
635	Subcutan.	"	....	8 weeks.	"	F. D. Lente.	Not stated.	New York Jour. of Med., vol. v., Nov. 1850.
636	"	"	5 weeks.	3 months.	"	W. S. Edgar.	"	St. Louis Med. and Surg. Jour., Oct. 1866.
637	Cut down.	"	11 days.	8 weeks.	"	J. Russell.	"	London Association Med. Jour., June, 1854.
638	....	"	....	7 weeks.	"	Dohlhoff.	"	Deutsche Klinik, p. 135, 1850.
639	Subcutan.	"	Not stated	Not stated	Failed.	Lawrence.	"	London Lancet, Aug. 22, 1857.
640	"	"Partial union at end of 3 weeks. Result not reported."	3 weeks.	4 weeks.	Relieved.	C. Heath.	"	London Lancet, vol. ii., 1871.
641	....	Not stated.	....	2 years.	Failed.	Not stated.	"	London Medical Times, July 19, 1850.
642	....	"Unable to put foot to ground."	....	3 years.	"	"	Extension.	London Medical Times, July 19, 1850.
643	Subcutan.	Not stated.	....	8 months.	Cured.	Tamplin.	"Various methods."	London Medical Times, July 19, 1850.
644	....	"	....	6 weeks.	"	D. Hayes Agnew.	Not stated.	Phila. Med. and Surg. Reporter, Nov. 2, 1867.
645	Subcutan.	"	....	4 weeks.	"	F. D. Lente.	"	New York Jour. of Med., vol. v., 1850.
646	"	"	....	9 weeks.	"	J. R. Wood.	"	N. Y. Amer. Med. Times, Jan. 1861.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
647	Tibia.	Lower third.	Compound, comminuted.	Not stated.	F.	32	Many mos.	Resection of both ends of tibia; sawing out one and a half inches of the unbroken fibula, which prevented tibia coming together.
648	"	"	Not stated.	"	F.	Ad.	9 months.	Resection of both ends.
649	"	"	"	Oblique.	M.	Ad.	Some time.	Drilling callus only.
650	"	"	"	"	M.	30	3 months.	Drilling ends, and repeated.
651	"	"	"	Not stated.	M.	Ad.	6 months.	Drilling ends of bone.
652	"	"	"	"	M.	Ad.	10 months.	Drilling ends of fragments, and Malgaigne's spikes.
653	"	"	"	"	M.	25	5 months.	Drilling ends, and repeated twice every nine days.
654	"	"	"	"	M.	34	6½ weeks.	Stirring up interposed mass with strong needle; starch bandage.
655	Fibula.	"	"	"	M.	21	2 months.	Drilling ends with gimlet, and allowed to remain.
656	"	"	"	"	M.	Ad.	15 weeks.	Forcible friction of ends frequently.
657	Humerus.	Not stated.	Not stated.	Not stated.	M.	52	2 years.	Amputation.
658	"	"	Comminuted.	"	M.	31	6 months.	"
659	"	Upper third.	Not stated.	"	M.	33	5 months.	"
660	"	Middle third.	"	"	M.	29	12 months.	"
661	"	Lower third.	"	"	M.	50	Not stated.	"
662	"	"	"	"	M.	62	2 years.	Amputation at shoulder-joint.
663	"	"	Compound.	"	F.	46	2 years.	Amputation.
664	Femur.	Not stated.	"	"	F.	34	15 months.	"
665	"	"	Not stated.	"	M.	28	3 months.	"
666	"	"	"	"	M.	60	7 months.	"
667	"	Upper third.	"	"	M.	27	2 years.	"
668	"	Middle third.	"	"	M.	60	21 months.	"
669	"	Middle.	"	"	M.	Ad.	2½ years.	"
670	"	"	Compound.	"	F.	33	15 months.	"
671	"	Junction of middle and lower thirds.	Not stated.	"	M.	6	2 years.	"
672	"	Lower third.	"	"	F.	51	11 months.	"
673	"	"	"	"	M.	40	20 months.	"
674	"	Condyles.	"	"	M.	27	2 years.	"
675	Tibia and fibula.	Not stated.	"	"	M.	34	6 months.	"
676	"	Middle.	Compound.	"	M.	37	6 months.	"
677	"	"	Not stated.	"	M.	15	1 year.	"
678	"	Lower third.	"	"	M.	Ad.	9 years.	"
679	"	"	"	"	M.	13	Many mos.	"
680	"	"	"	"	M.	Ad.	3 months.	"

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
647	Cut down.	2 to 3 inches shortening	....	Not stated	Cured.	J. M. Banner.	Not stated.	Edinburgh Medical and Surg. Jour., vol. lix., 1843.
648	"	Erysipelas.	....	"	"	Toogood.	"	Provincial Medical Jour., Jan.–March, 1843.
649	"	"Muscle found interposed."	....	Some wks	Failed.	D. Prince.	"	Chicago Med. Examiner, Dec. 1863.
650	Subcutan.	Not stated.	....	3 weeks.	Cured.	"	"	Chicago Med. Examiner, Dec. 1863.
651	"	"	....	4 months.	Failed.	"	"	Chicago Med. Examiner, Dec. 1863.
652	"	Chills.	28 days.	6 weeks.	Cured.	"	Drilling.	Chicago Med. Examiner, Dec. 1863.
653	"	Not stated.	....	5 weeks.	"	D. Brainard.	Not stated.	Chicago Medical Journal, Sept. 1858.
654	"	"	....	8 weeks.	"	J. Miller.	"	Edin. Month. Jour. Med. Sci., vol. ii., 1847–48.
655	"	"	....	7½ wks.	"	D. Hayes Agnew.	"	Records of Surgical Wards of Penna. Hospital.
656	....	"	....	5 weeks.	"	Hecker.	"	(Prager) Vierteljahrsschr. Heilk. Prakt., 1854. (Gurlt's Surgery)
657	....	No bad result.	....	....	....	Darby.	Seton, resection.	Dublin Medical Press, vol. xxvii., 1852.
658	....	....	....	....	....	Jobert (de Lamballe).	Seton.	Gazette des Hôpitaux, p. 14, 1851.
659	....	....	....	....	....	S. E. Löwenhardt.	Not stated.	Appts. zur Behandlg. d. Knochenbr., 1840. (Gurlt's Surgery.)
660	....	....	....	....	....	Arnott.	Resection.	London Medical Times, Oct. 11, 1845.
661	....	....	....	....	....	Von Bruns.	Resection, and wire ligature.	Deutsche Klinik, B. xxviii., 1861.
662	....	"Patient got well."	....	....	....	H. A. Lediard.	Not stated.	London Lancet, Oct. 11, 1873.
663	....	....	....	....	....	H. J. Bigelow.	Resection, and wiring together.	Boston Medical and Surg. Jour., May, 1867.
664	....	....	....	....	....	G. W. Norris.	Seton, pressure.	Amer. Jour. Med. Sci., Jan. 1849.
665	....	....	....	....	....	N. Y. Hospitals.	Not stated.	Malgaigne on Fractures. (Translated by Packard.)
666	....	....	....	....	....	"	"	Malgaigne on Fractures. (Translated by Packard.)
667	....	....	....	....	....	Stanley.	Resection, drilling ends, and 3 ivory pegs.	London Lancet, Nov. 1854.
668	....	....	....	....	....	J. Erichsen.	Ivory pegs; drilling, and wired together.	London Med. Times and Gazette, vol. xi., 1855.
669	....	....	....	....	....	Mackenzie.	Ivory pegs.	London Association Med. Jour., Feb. 10, 1854.
670	....	....	....	....	....	G. W. Norris.	Seton, pressure.	Norris, Contributions to Practical Surgery, 1873.
671	....	....	....	....	....	H. Coote.	Ivory pegs.	London Lancet, vol. i., 1862.
672	....	....	....	....	....	Butlin.	Resection, and 2 steel pegs.	London Lancet, Feb. 14, 1874.
673	....	"Gangrene."	....	5 days.	Died.	Holt.	Not stated.	London Lancet, vol. ii., 1849.
674	....	"Tied femoral artery for secondary hemorrhage."	....	....	....	J. Paget.	Friction.	London Medico-Chirurg. Trans., vol. li., 1868.
675	....	....	....	....	....	W. Günther.	Not stated.	(Prager) Vierteljahrsschr. Prakt. Heilk., 1859. (Gurlt's Surgery.)
676	....	....	....	....	....	J. Syme.	"	London Med. Times, vol. xix.–xx., 1848–1849.
677	....	....	....	....	....	J. Watson.	"	New York Medical Times, October, 1851.
678	....	....	....	....	....	Gay.	"	London Med. Times, N. S., 1850.
679	....	....	....	....	....	A. Key.	"	London Medical Gazette, vol. iv., 1829.
680	....	....	....	....	....	J. Heyfelder.	Resection.	Deutsche Klinik, p. 397, 1856.

Ununited

No.	Bone.	Seat of Fracture.	Original Character.	Direction.	Sex.	Age.	Time it had existed.	Operation, and how performed.
681	Tibia.	Not stated.	Not stated.	Not stated.	M.	22	10 months.	Amputation.
682	"	Middle.	"	"	M.	30	13 months.	"
683	"	Middle third.	"	"	M.	8	4½ years.	"
684	"	Lower third.	"	"	M.	Boy	4 years.	"
685	"	"	Compound.	"	M.	52	15 weeks.	"

Results of Different Methods of

Number.	Mode of Treatment employed.	Inferior Maxillary.					
		No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	Scraping the ends of the fragments, through an external opening	1	1	...	...	...	...
2	" " " subcutaneously	1	...	...	...	1	...
3	External splints, or apparatus, simply	1	1	...	...	...	...
4	" " " and teeth wired together	2	2	...	...	...	...
5	Interdental splint, metal or rubber, simply	3	2	1	...	...	...
6	" " " " and teeth wired together	1	...	...	...	1	...
7	Drilling ends of fragments, or perforating them	2	2	...	...	...	...
8	" " " and the drill left in	1	1	...	...	...	...
9	" " " and wiring them together	3	3	...	...	...	...
10	" " " and uniting them by copper nails	1	1	...	...	...	...
11	Seton	...	...	...	...	...	...
12	Acupuncture	...	...	...	...	...	...
13	Resection	...	...	...	...	...	...
	Total	16	13	1	...	2	...

In making our deductions from the table of the Results of the different methods of treatment of pseudar-*all* of the 7 cases in which *drilling*, together with its modifications, was performed; this also was the case when reported. Friction, by scraping the ends through an external opening, was successful in the 1 case recorded,

Fractures.

No.	Cut down on; or subcutaneously.	Sequelæ.	Time wire, etc., remained.	Length of Treatment.	Result.	Surgeon.	Previous Treatment.	Work quoted from.
681	....	....	....	....	....	Arnott.	Not stated.	London Medical Gazette, N. S., vol. ii., 1840.
682	....	....	....	....	....	J. Russell.	Seton, friction.	London Association Med. Jour., June, 1854.
683	....	....	....	....	....	H. Coote.	Not stated.	Lond. Lancet, vol. i., 1862.
684	....	....	....	....	....	Lawrence.	Seton.	Lond. Lancet, Aug. 22, 1857.
685	....	....	....	....	....	J. Erichsen.	Not stated.	Lond. Lancet, vol. i., 1863.

Treatment of Pseudarthrosis.

Number.	Clavicle.						Scapula.						Metacarpus.						Ribs.					
	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	...	...	...	...	...	...	1	...	1	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
	1	1	...	...	...	...	1	...	1	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...

throsis of the Inferior Maxillary, we find that of the whole number of cases treated, success was attained in the teeth were wired together and the *external* splint, or apparatus, was applied, as noted in the three cases while, strange to say, when attempted subcutaneously, the patient died.

Results of Different Methods of Treat-

Number.	Mode of Treatment employed.	Location not given. No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Surgical Neck. No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	Scraping, scratching, or lacerating the ends	2	2	...	...	...	...	...	...	...	...	...	...
2	" " " " subcutaneously	3	2	1	...	...	...	...	...	...	...	...	...
3	Forcible friction of the ends together	1	1	...	...	...	...	...	...	...	...	...	...
4	Friction of the ends, by carrying the arm in H. H. Smith's apparatus	1	...	1	...	...	...	1	...	1	...	...	...
5	Acupuncture by needles, or by trocar and canula	1	...	1	...	...	...	...	...	...	...	...	...
6	Electro-puncture	1	1	...	...	...	...	...	...	...	...	...	...
7	Local counter-irritation by iodine and blisters	1	1	...	...	...	...	...	...	...	...	...	...
8	Immovable dressing of starch, glue, etc	2	2	...	...	...	...	...	...	...	...	...	...
9	Firm pressure	1	...	...	1	...	...	...	...	...	...	...	...
10	Different kinds of apparatus; splints; tonic treatment	1	1	...	...	...	...	...	...	...	...	...	...
11	Seton, of silk, thread, horse-hair, or wire	11	4	4	3	...	...	...	...	...	...	...	...
12	Resection	15	7	...	8	...	...	...	...	...	...	...	...
13	" and immovable dressing of starch, etc	...	...	...	...	...	...	...	...	...	...	...	...
14	" and steel screws bored into the ends	1	...	...	1	...	...	1	...	...	1	...	...
15	" drilling, and uniting the ends by wire or thread	5	...	2	2	1	...	...	...	...	...	...	...
16	" " after reflecting the periosteum, and uniting the ends by wire or thread.	1	1	...	...	...	...	...	...	...	...	...	...
17	Drilling, or perforating the ends; subcutaneously	1	1	...	...	...	...	1	...	...	1	...	...
18	" " " and drill left in; subcutaneously	...	...	...	...	...	...	...	...	...	...	...	..
19	" " " and ivory pegs, or steel screws, put in; subcutaneously	3	2	...	1	...	...	...	...	...	...	...	...
20	" " " and the fragments wired together	...	...	...	...	...	...	1	1	...	...	...	...
21	Joint was opened; drilling, and ivory pegs, or steel screws, were put in the ends	1	...	1	...	...	...	...	...	...	...	...	...
22	Ptyalism	...	...	...	...	...	...	...	...	...	...	...	...
	Total	52	25	10	16	1	..	4	1	1	2	...	...

In number 10 of the table, containing Results of the treatment of non-union of the Humerus by different kinds apparatus for fractured clavicle, and was cured: 1 was cured by the swinging angular splint: and 1 was cured By drilling, after first performing resection, and uniting the ends of the bone by wire, etc., 32 cases were 35 cases were treated, of which 21 were cured, 2 were relieved, 11 failed, and in 1 the result was not stated. In result was not stated.

Results of Different Methods of Treatment

Number.	Mode of Treatment employed.	Location not given. No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Junction of Upper and Middle Thirds. No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Middle Third. No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	Scraping the ends; subcutaneously	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	Friction of the ends together, forcibly	2	...	...	2	...	...	...	...	...	...	...	...	1	...	...	1	...	...
3	Acupuncture	2	1	1	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
4	Immovable dressing of starch, etc	1	...	...	1	...	...	...	...	...	...	...	..	...	...	...	...	...	...
5	Tincture of iodine, locally, as a counter-irritant	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	Firm pressure	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	Apparatus; rest; splints; tonic treatment	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	Seton	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9	Resection	2	1	1	...	..	...	2	1	...	1	...	...	1	...	...	1	...	...
10	" and an immovable dressing of starch, etc	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	" and the ends united by wire ligature	2	1	...	1	...	...	2	2	...	...	...	...	...	...	...	...	...	...
12	" drilling fragments, and ends of bone united by wire ligature.	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13	Drilling or perforating ends; subcutaneously	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...
14	" " " and pegs driven in	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Total	15	8	3	4	...	...	4	3	...	1	...	...	4	1	...	3	...	...

In the table of treatment of the Radius and Ulna, 1 case was treated by Boyer's apparatus, and was cured: uniting bones by wire, 3 cases were treated, of which 2 were cured and 1 failed; but when drilling and its modi- drilling was 7 treated, of which number 2 were cured, 1 was relieved, and 4 failed.

ment of Pseudarthrosis of the Humerus.

Upper Third.						Junction of Upper and Middle Thirds.						Middle.						Middle Third.						Junction of Middle and Lower Thirds.						Lower Third.						Whole Number treated.					
No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	4	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	...	...	1	...	...	6	2	1	3	...	...
1	...	...	1	...	...	...	...	.	...	...	...	7	2	...	5	...	...	...	...	...	...	...	...	1	...	...	1	...	...	3	1	...	2	...	...	13	4	...	9	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	.....	2	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	2	1	1	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...
2	...	...	2	...	...	...	...	...	...	...	...	6	1	...	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	3	2	1	...	...	...	13	5	1	6	1	...
3	1	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	...	...	1	...	...	6	1	...	5	...	...
...	...	...	...	...	...	...	...	...	...	...	...	3	2	1	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...	2	2	...	...	...	...	8	6	1	1	...	...
1	...	...	1	...	...	3	3	...	...	...	...	14	4	...	9	1	...	1	1	...	...	...	...	4	...	...	3	...	1	8	...	...	8	...	...	42	12	4	24	1	1
2	2	...	...	...	...	...	...	...	...	...	...	15	8	...	6	1	...	1	...	...	1	...	...	3	1	1	1	...	...	6	4	...	1	...	1	42	22	1	17	1	1
...	...	...	...	...	...	...	...	...	...	...	...	4	3	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	3	..	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	2	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	5	.....	1	4	...	...
...	...	...	...	...	...	...	...	...	...	...	...	4	4	...	...	...	...	2	2	...	...	...	...	5	2	1	2	...	...	5	1	1	3	...	...	21	9	4	7	1	...
...	...	...	...	...	...	1	1	...	...	...	...	3	3	...	...	...	...	4	3	...	1	...	...	...	...	...	...	...	...	2	1	...	1	...	...	11	9	...	2	...	...
1	1	...	...	...	...	...	...	...	...	...	...	4	1	1	2	...	...	3	2	...	1	...	...	...	...	...	...	...	...	4	1	...	3	...	...	14	6	1	7	...	...
1	...	...	1	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	..	...	1	1	...	...	...	...	4	3	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	5	3	...	2	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	10	7	...	3	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	..	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	4	4	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	1	1	...	...	...	...	3	1	1	...	...	1
1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...
12	5	...	7	...	...	4	4	...	...	...	...	71	34	3	31	3	...	14	9	...	5	...	...	21	7	2	10	...	2	41	17	2	21	...	1	219	102	18	92	4	3

of apparatus, 4 were treated by splints, with a result of 3 cured and 1 failed. One was treated by Crawford's by first extracting a loose external condyle, and then applying an apparatus.
treated, of which 18 were cured, 4 were relieved, 9 failed, and 1 died. By drilling, together with its modifications, all, by drilling, 67 cases were treated: of these, 39 were cured, 6 were relieved, 20 failed, 1 died, and in 1 the

of Pseudarthrosis of the Radius and Ulna.

Middle.						Junction of Middle and Lower Thirds.						Lower Third.						Whole Number treated.					
No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	...	...	1	...	...
1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	1	...	3	...	...
1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	3	1	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...
...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	1	...	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	3	2	...	1	...	...
1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
2	1	...	1	...	...	1	1	...	...	...	...	...	...	...	...	...	...	8	4	1	3	...	...
...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	3	...	1	...	...
1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	2	...	1	...	...
1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	2	...	1	1	...	...
7	4	...	3	...	...	5	3	...	2	...	...	2	...	...	2	...	...	37	19	3	15	...	...

2 cases were treated by the ordinary splints, 1 of which was cured and 1 failed. By drilling, after resection, and fications were used alone, of the 4 cases treated, none were cured, 1 only was relieved, and 3 failed. The total by

Results of Different Methods of Treat-

Number.	Mode of Treatment employed.	Location not stated.						Upper Third.					
		No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	Scraping, lacerating, or scratching the ends	...	...	...	...	...	...	...	...	...	...	...	...
2	Friction, by forcibly rubbing the ends together	...	...	...	...	...	...	...	...	...	...	...	...
3	Acupuncture	2	2	...	...	...	...	...	...	...	...	...	...
4	Local counter-irritation, etc., by tincture of iodine	...	...	...	...	...	...	...	...	...	...	...	...
5	Firm pressure	...	...	...	...	...	...	...	...	...	...	...	...
6	Splints; rest, and tonic treatment	...	...	...	...	...	...	...	...	...	...	...	...
7	Seton of wire, or silk	...	...	...	...	...	...	1	...	...	1	...	...
8	Resection	3	3	...	...	...	...	1	1	...	...	...	...
9	" drilling, and wiring the ends of the bone together	2	1	...	1	...	...	...	...	...	...	...	...
10	" " after reflecting the periosteum, and wiring the ends together	1	1	...	...	...	...	...	...	...	...	...	...
11	Drilling the ends; subcutaneously	...	...	...	...	...	...	...	...	...	...	...	...
12	" " " after a diagonal resection of them; the needle was left in	...	...	...	...	...	...	1	1	...	...	...	...
13	Drilling, and wiring the fragments together	1	...	...	1	...	...	1	1	...	...	...	...
14	Actual cautery	1	1	...	...	...	...	...	...	...	...	...	...
	Total	10	8	...	2	...	...	4	3	...	1	...	...

From the table containing the Results of treatment of non-union of fractures in the Radius only, we find that, cured, and 1 failed; and that, by drilling, with its modifications, 3 cases were treated, of which 2 were cured, and

Results of Different Methods of Treat-

Number.	Mode of Treatment employed.	Location not stated.						Upper Third.						Middle Third.					
		No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	Scraping, lacerating, or scratching the ends	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	Friction, by forcibly rubbing the ends together	2	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	..
3	Acupuncture	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	Local counter-irritation, etc., by tincture of iodine	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	Firm pressure	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
6	Splints; rest, and tonic treatment	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	Seton of wire, or silk	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	Resection	2	...	...	1	...	1	1	...	...	1	...	...	...	...	...	...	...	...
9	" drilling, and wiring the ends of the bone together	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	" " after reflecting the periosteum, and wiring the ends together	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	Drilling the ends; subcutaneously	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
12	" " " after a diagonal resection of them; the needle was left in	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13	Drilling, and wiring the fragments together	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
14	Actual cautery	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Total	8	5	...	2	...	1	2	1	...	1	...	...	1	1	...	...	...	...

From the same table we find that, where the Ulna only was ununited, and drilling was the method used, after cases were treated, of which 4 were cured and 1 failed: giving a total, by drilling, of 6 cases treated, with a result

ment of Pseudarthrosis of the Radius.

Middle.						Junction of Middle and Lower Thirds.						Lower Third.						Whole Number treated.					
No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	3	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	...	...	1	...	...	1	1	...	...	...	...	2	1	...	1	...	...
1	1	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	3	1	...	2	...	...
...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...	6	5	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
2	2	...	...	...	...	2	1	...	1	...	...	5	3	...	2	...	...	23	17	...	6	...	...

by drilling, after resecting the ends of the bone and uniting them by wire, 4 cases were treated, of which 3 were 1 failed; giving a total, by drilling, of 7 cases treated, with a result of 5 cures and 2 failures.

ment of Pseudarthrosis of the Ulna.

Middle.						Junction of Middle and Lower Thirds.						Lower Third.						Whole Number treated.					
No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	2	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	2	...	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1	1	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	4	3	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	2	...	...	...	...	2	1	...	1	...	...	1	1	...	...	...	...	16	11	...	4	...	1

resecting the ends of the bone, the only case treated was cured; and that, by drilling, with its modifications, 5 of 5 cures, and 1 failure.

Results of Different Methods of Treat-

Number.	Mode of Treatment employed.	Location not given. No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Neck. No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	Scraping, scratching, or lacerating the ends; subcutaneously	2	...	...	1	...	1	...	...	...	...	...	...
2	Forcible friction of the ends together	2	2	...	...	...	...	2	1	...	1	...	...
3	Friction of the ends, by allowing patient to walk about in an apparatus	3	1	1	1	...	...	...	...	...	...	...	...
4	Acupuncture	1	...	...	1	...	...	1	1	...	...	...	...
5	Electro-puncture	1	1	...	...	...	...	...	...	...	...	...	...
6	Local counter-irritation by tincture of iodine	7	6	...	1	...	...	1	1	...	...	...	...
7	Immovable dressing of starch, glue, leather, etc	4	3	...	1	...	...	2	1	...	1	...	...
8	Malgaigne's spikes	1	1	...	...	...	...	...	...	...	...	...	...
9	Firm pressure	6	4	...	2	...	...	...	...	...	...	...	...
10	Extension and counter-extension, without splints	...	...	...	...	...	...	...	...	...	...	...	...
11	Different kinds of apparatus; splints, and tonic treatment	6	6	...	...	...	...	2	1	...	...	1	...
12	Injection of liquor ammoniæ into the false joint	...	...	...	...	...	...	...	...	...	...	...	...
13	Seton of thread, silk, or wire	4	1	...	2	1	...	...	...	...	...	...	...
14	Resection	10	8	...	...	2	...	...	...	...	...	...	...
15	" and wiring ends of bone together	2	2	...	...	...	...	...	...	...	...	...	...
16	" drilling, and wiring ends of bone together	...	...	...	...	...	...	...	...	...	...	...	...
17	" " after reflecting periosteum, and wiring ends of bone together	...	...	...	...	...	...	...	...	...	...	...	...
18	" " and ivory pegs driven in	...	...	...	...	...	...	...	...	...	...	...	...
19	Drilling, or perforating ends; subcutaneously	3	2	...	1	...	...	...	...	...	...	...	...
20	" " " and drill left in; subcutaneously	2	1	...	1	...	...	...	...	...	...	...	...
21	" " " and ivory pegs driven in; subcutaneously	1	1	...	...	...	...	...	...	...	...	...	...
22	" " " and wiring the ends of bone together	...	...	...	...	...	...	...	...	...	...	...	...
	Total	55	39	1	11	3	1	8	5	...	2	1	...

It will appear from the above table that of the 17 cases treated by forcible friction, 7 were cured and 10 failed: By Lilley's apparatus, invented in 1854, 1 case was cured. By H. H. Smith's splint, 6 cases were treated, with on crutches, having the limb firmly bandaged, and both were cured, while of 4 cases which were allowed to and of Dzondc, together with rest, 3 were cured. By Middledorps' swinging mechanism, 4 were treated, with 4 alone, 5 were cured, 4 failed, and 2 died; by drilling, with its modifications, 18 cases were treated, with 9 cures, 8

Results of Different Methods of Treatment of

Number.	Mode of Treatment employed.	Location not given. Treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	Scraping, scratching, or lacerating ends; subcutaneously	3	3	...	...	...	...
2	Forcible friction of the ends together	3	3	...	...	...	...
3	Friction of the ends, by walking on crutches or in an apparatus	3	3	...	...	...	...
4	Acupuncture	...	...	...	...	...	...
5	Electro-puncture	...	...	...	...	...	...
6	Galvanism, externally, in length of limb, or locally	2	2	...	...	...	...
7	Local counter-irritation by tincture of iodine and blisters	3	3	...	...	...	...
8	Immovable dressing of starch, leather, etc	1	1	...	...	...	...
9	Firm pressure	1	1	...	...	...	...
10	Different apparatus; splints, and tonic treatment	1	...	...	1	...	...
11	Phosphate of lime, internally	...	...	...	...	...	...
12	Caustics to ends of bone	1	1	...	...	...	...
13	Seton of silk, thread, or wire	1	1	...	...	...	...
14	Tenotomy of tendons of contracted muscles	1	1	...	...	...	...
15	Resection	4	3	1	...	...	...
16	" and fragments wired together	1	...	...	...	1	...
17	" drilling, after reflecting periosteum, and ends wired	1	1	...	...	...	...
18	" and actual cautery to ends	1	1	...	...	...	...
19	Drilling, or perforating ends; subcutaneously	1	...	1	...	...	...
20	" " " and ivory pegs driven in; subcutaneously	1	1	...	...	...	...
21	Ivory pegs driven into ends; not subcutaneously	...	...	...	...	...	...
22	Ptyalism and starch bandage	1	1	...	...	...	...
	Total	30	26	2	1	1	...

In the treatment of non-union of the Tibia and Fibula, H. H. Smith's apparatus was used twice, with 2 cures, and of 10 cases managed by splints of different kinds, 7 were cured, and 3 failed. Drilling, with its modifications,

ment of Pseudarthrosis of the Femur.

Upper Third.						Junction of Upper and Middle Thirds.						Middle.						Middle Third.						Junction of Middle and Lower Thirds.						Lower Third.						Whole Number treated.					
No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.	No. treated.	Cured.	Relieved.	Failed.	Died.	Not given.
...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	1	1	1
2	1	...	1	...	...	...	...	...	...	...	...	6	3	...	3	...	...	1	...	...	1	...	...	2	...	...	2	...	...	2	...	...	2	...	...	17	7	...	10	...	...
4	3	...	1	...	...	2	2	...	...	...	...	4	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	14	10	2	2	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	...	...	1	...	...	4	1	..	3	...	...
...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	2	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8	7	...	1	...	...
1	...	...	1	...	...	...	...	...	...	...	...	3	1	...	2	...	...	1	1	...	...	...	...	2	1	...	1	...	...	...	...	...	...	...	...	13	7	...	6	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	4	2	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	11	7	...	4	...	...
1	1	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...
...	...	...	...	...	...	1	...	...	1	...	...	5	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	15	12	...	2	1	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...
2	2	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...	3	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11	6	...	4	1	...
2	1	1	...	...	...	1	...	...	...	1	...	1	1	...	...	...	...	1	...	...	...	1	...	1	...	...	...	1	...	2	1	...	...	1	...	18	11	1	...	6	...
...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	3	...	...	...	...
2	1	...	...	1	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	5	4	...	..	1	...
...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
2	...	...	1	1	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...	5	...	...	4	1	...
...	...	...	...	...	...	1	1	...	...	...	...	3	1	...	2	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	8	5	...	3	...	...
...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	5	3	...	1	1	...
...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	4	1	...	3	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...
16	9	1	4	2	...	7	5	...	1	1	...	39	21	1	16	1	...	8	5	...	2	1	...	10	4	...	5	1	...	12	4	...	6	2	...	155	92	3	47	12	1

of the 14 treated by a walking apparatus, which is modified friction, 10 were cured, 2 were relieved, and 2 failed.
4 cures. To R. Moyle's appliance, by which 1 case was cured, no name is given. 2 patients were allowed to walk
walk with the leg in an immovable dressing, 2 were cured and 2 failed. By the apparatus of Boyer, of Desault,
cures. Of 6 cases treated by splints and rests, 4 were cured, 1 failed, 1 died. Of 11 cases subjected to drilling
failures, and 1 death: giving a total by drilling of 29 cases, with 14 cures, 12 failures, and 3 deaths.

Pseudarthrosis of the Tibia, Fibula, and Patella.

Tibia and Fibula.																																				Patella.					
Junction of Upper and Middle Thirds.						Middle.						Middle Third.						Junction of Middle and Lower Thirds.						Lower Third.						Whole Number treated.						Whole Number treated.					
Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	4	3	...	1	...	...	...	...	...	...	...	...
1	1	...	...	...	...	2	1	1	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...	2	1	...	1	...	...	10	7	1	2	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...	5	4	...	1	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	3	3	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	6	5	...	1	...	...	11	10	...	1	...	...	1	1	...	...	...	...
...	...	...	...	...	...	4	2	...	2	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	7	5	...	2	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	3	2	...	1	...	...	...	...	...	...	...	...
...	...	...	...	...	...	5	4	...	1	...	...	1	1	...	...	...	...	2	2	...	...	...	...	1	...	...	1	...	...	10	7	...	3	...	...	2	...	2	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...	4	3	...	1	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	...	1	...	...	...
...	...	...	...	...	...	3	3	...	...	...	...	...	...	...	...	...	...	4	2	...	2	...	...	4	1	...	3	...	...	15	9	1	5	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	...	1	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	3	...	...	...	...	5	4	1	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...	4	3	...	1	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
1	1	...	...	...	...	22	16	1	5	...	...	6	6	...	...	...	...	9	6	...	3	...	...	26	16	...	10	...	...	94	71	3	19	1	...	6	3	3	...	...	...

Of 6 cases treated by firm bandaging, the patients being allowed to walk on crutches, 5 were cured, and 1 failed;
was employed in 11 cases, with 9 cures and 2 failures.

Results of Different Methods of Treatment of

Number.	Mode of Treatment employed.	Location not given.					
		Treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	Scraping, scratching, or lacerating ends; subcutaneously	1	1	...	...	...	...
2	Forcible friction of ends together	1	...	1	...	...	...
3	Friction of ends, by walking in apparatus	1	1	...	...	...	...
4	Acupuncture	2	1	1	...	...	...
5	Electro-puncture, and immovable apparatus	...	...	...	...	...	...
6	Galvanism in length of limb, or over fracture	2	2	...	...	...	...
7	Local counter-irritation by tincture of iodine, or blisters	...	...	...	...	...	...
8	Malgaigne's spikes	...	...	...	...	...	...
9	Different apparatus; splints; tonic treatment	2	1	...	1	...	...
10	Injection of argenti nitratis into false joint	...	...	...	...	...	...
11	Caustics to ends of bone	2	2	...	...	...	...
12	Seton of silk, wire, or thread	6	1	4	1	...	...
13	Tenotomy of the contracted muscles, and forcible extension	...	...	...	...	...	...
14	Resection	6	5	...	1	...	...
15	" drilling the ends, and wiring the ends together	2	2	...	...	...	...
16	" of tibia, and intentional fracture of fibula	...	...	...	...	...	...
17	Intentional fracture of fibula, and forcible friction of tibia	1	...	1	...	...	...
18	Drilling, or perforating the ends; subcutaneously	7	4	...	3	...	...
19	" " " " and Malgaigne's spikes	...	...	...	...	...	...
20	" " " " and drill left in	1	...	...	1	...	...
21	" " " " and ivory pegs driven in	2	...	1	1	...	...
22	Ptyalism	...	...	...	...	...	...
	Total	36	20	8	8	...	...

From the table containing the Results of the treatment of ununited fracture of the Tibia, we find that where treated and cured, as was also 1 treated and cured by encasing the leg in a starch bandage and allowing locomo- were treated by H. H. Smith's appliance and were cured; making a total of 5 cases, treated by friction of the cured. When the patient was kept at rest, and splints were used, 4 cases were treated, of which 2 were cured, and used in 1 case, and failed; so that we get a total of 6 cases treated by splints, or apparatus, and of this number

Where the method of drilling the ends of the bone, after resecting, was used, 4 cases were treated, and all 4 cured, 3 were relieved, and 7 failed; giving a total number of 29 cases treated by drilling, of which number 19

Where the Fibula only was ununited, forcible friction of the ends cured 1 case, and drilling the ends, with the not so, were all that are recorded as such in 685 cases of pseudarthrosis.

Results of Treatment of Pseudar-

Time the Seton remained.	Clavicle.		Humerus.						Rad. and Ulna.		Radius.				
	Treated.	Cured.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Treated.	Cured.	Relieved.	Failed.	Died.
From one to six days	...	...	2	...	...	1	1	...	...	...	1	...	...	1	...
" seven to ten days	...	...	10	4	1	4	...	1	...	...	...	...	...	...	...
" fourteen to sixteen days	...	...	4	2	1	1	...	...	...	...	...	...	...	...	...
" twenty-one to twenty-three days	1	1	3	1	...	2	...	...	...	...	1	...	...	1	...
" twenty-eight to thirty days	...	...	3	2	...	1	...	...	...	...	...	...	...	...	...
For five weeks	...	...	2	...	...	2	...	...	...	...	...	...	...	...	...
" six weeks	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...
" seven weeks	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
From eight to nine weeks	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...
For thirteen weeks, or three months	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...
From seventeen to nineteen weeks	...	...	2	...	...	2	...	...	...	...	...	...	...	...	...
For six months	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...
" seven months	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...
" eleven months	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...
Time not stated	...	...	10	1	2	7	...	...	1	1	1	1	...	...	...
Total	1	1	42	12	4	24	1	1	1	1	3	1	...	2	...

Pseudarthrosis of the Tibia and Fibula.

Tibia.																																				Fibula.					
Upper Third.						Middle.						Middle Third.						Junction of Middle and Lower Thirds.						Lower Third.						Whole Number treated.						Whole Number treated.					
Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.
...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	2	1	...	1	...	...	4	2	...	2	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	3	2	1	...	...	...	1	1	...	...	...	...
1	1	...	...	...	...	3	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	5	...	...	...	...	...	...	...	...	...	...
1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	1	1	1	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	1	...	...	...	...	1	1	...	...	...	...	3	2	...	1	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	2	...	...	2	...	...	6	2	...	4	...	...	...	...	...	...	...	...
1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...
1	...	...	1	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	10	3	4	3	...	...	...	..	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	...	...	1	...	...	1	...	1	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	9	6	1	2	...	...	...	...	...	...	...	...
...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	4	4	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...
1	1	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	4	3	...	1	...	...	14	10	...	4	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	4	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	6	4	1	1	...	...	1	1	...	...	...	...
...	...	...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	4	...	2	2	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...
5	2	...	3	...	...	14	12	1	1	...	...	7	3	1	3	...	...	6	5	...	1	...	...	16	10	1	5	...	...	84	52	11	21	...	...	2	2	...	...	...	...

friction was produced, by allowing patient to walk about on crutches, with the leg firmly bandaged, 1 case was
tion on crutches; walking about, with the leg firmly fixed in a leathern apparatus, cured 1 case; and 2 cases
ends of the bone, produced by walking about in splints, or in an apparatus, firmly fitting the leg, and all were
2 failed; and 1 case failed in which splints and forcible extension were used. Amesbury's apparatus was also
only 2 were cured, while 4 failed.
were cured; where drilling and its modifications were used, 25 cases were treated, of which number 15 were
were cured, 3 were relieved, and 7 failed.
drill allowed to remain, cured the other; these 2 cases of the fibula being found ununited when the tibia was

throsis by the use of the Seton.

Femur.						Patella.		Tibia and Fibula.					Tibia.					Whole Number treated.					
Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Treated.	Cured.	Relieved.	Failed.	Died.	Treated.	Cured.	Relieved.	Failed.	Died.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.
1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	1	...	2	1	...
...	...	...	...	...	...	...	...	2	2	...	...	...	1	1	...	...	...	13	7	1	4	...	1
1	1	...	...	...	...	1	1	...	...	...	...	...	1	...	1	...	...	7	4	2	1	...	...
2	...	...	1	1	...	...	...	...	...	...	...	...	1	1	...	...	...	8	3	...	4	1	...
...	...	...	...	...	...	...	...	2	1	...	1	...	1	...	...	1	...	6	3	...	3	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
1	1	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	3	3	...	...	...	...
1	...	...	1	...	...	...	...	...	...	...	...	...	1	...	...	1	...	3	...	...	3	...	...
2	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	1	...	3	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...
2	1	...	1	...	...	...	...	...	...	...	...	...	4	...	3	1	...	18	4	5	9	...	...
11	6	...	4	1	...	1	1	4	3	...	1	...	10	3	4	3	...	73	28	8	34	2	1

Results of Different Methods of Treatment of Pseudar-

Number.	Mode of Treatment employed.	Inferior Maxillary. Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Clavicle. Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Scapula. Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Ribs. Treated.	Cured.	Relieved.
1	Scraping, scratching, or lacerating the ends of bone	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	" " " " " subcutaneously	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	Forcible friction of the ends of bone together	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	Friction of the ends of bone by moving, or walking about, in an apparatus	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	Acupuncture with needles, or trocar and canula	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	...	...	...
6	Electro-puncture	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	Galvanism, externally, to limb	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	Interdental splint of rubber or metal	3	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9	" " and wiring teeth together	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	External " " " "	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	Local counter-irritation by tincture of iodine or blisters	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	Immovable dressing of starch, glue, leather, etc	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13	Malgaigne's spikes	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
14	Firm pressure	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	Extension and counter-extension, without splints	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
16	Different kinds of apparatus; splints; rest; tonic treatment	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
17	Injection of liquor ammoniæ into false joint	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
18	" argenti nitratis into false joint	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19	Phosphate of lime, internally	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20	Caustics to the ends of bone	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
21	Seton of silk, wire, or thread	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...
22	Tenotomy of contracted muscles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
23	Actual cautery	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
24	Resection	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...
25	" and immovable dressing of starch, etc	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
26	" and steel screws bored into ends	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
27	" and the ends of the bone wired together	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
28	" drilling, and the ends of the bone wired together	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
29	" " after reflecting periosteum, and the ends of the bone wired together	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	Resection, drilling, and ivory pegs driven in	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
31	" " and drill left in	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
32	" and actual cautery applied to the ends of bone	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
33	" of tibia, and intentional fracture of fibula	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
34	Intentional fracture of fibula, and forcible friction of tibia.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
35	Drilling, or perforating, the ends of bone; subcutaneously	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
36	" and ivory pegs or steel screws driven in; subcutaneously	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
37	Drilling, and drill left in; subcutaneously	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
38	" and Malgaigne's spikes; subcutaneously	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
39	" and ivory pegs, or steel screws, driven in	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
40	" and the ends of bone united by wire	3	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
41	Ptyalism, and starch bandage	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
42	Ptyalism	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Total	16	13	1	...	2	...	1	1	...	...	...	...	1	...	1	...	...	...	1	1	...

Amputation was performed for the relief of Pseudarthrosis 29 times. The bones operated on

throsis; not including Amputations. Grand Total.

Metacarpus.			Humerus.						Radius and Ulna.						Femur.						Tibia and Fibula.						Patella.						Whole Number treated.					
Treated.	Cured.	Relieved.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.	Treated.	Cured.	Relieved.	Failed.	Died.	Not given.
...	...	...	4	4	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	7	...	...	...	...
...	...	...	6	2	1	3	...	...	1	...	...	1	...	...	3	...	...	1	1	1	8	5	...	3	...	...	...	...	...	...	...	...	19	7	1	8	2	1
...	...	...	13	4	...	9	...	...	7	3	...	4	...	...	17	7	...	10	...	...	14	10	2	2	...	...	...	...	...	...	...	...	51	24	2	25	...	...
...	...	...	2	...	2	...	...	...	...	...	...	...	...	...	14	10	2	2	...	...	10	9	...	1	...	...	...	...	...	...	...	...	26	19	4	3	...	...
1	1	...	2	1	1	...	...	...	8	7	1	...	...	...	4	1	...	3	...	...	4	1	1	2	...	...	...	...	...	...	...	...	20	11	4	5	...	...
...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	3	2	...	1	...	...	5	4	...	1	...	...	...	...	...	...	...	...	9	7	...	2	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	5	...	...	...	...	...	...	...	...	...	...	5	5	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	2	1	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...
...	...	...	2	1	...	1	...	...	2	1	...	1	...	...	8	7	...	1	...	...	13	12	...	1	...	...	1	1	...	...	...	...	26	22	...	4	...	...
...	...	...	13	5	1	6	1	...	1	...	...	1	...	...	13	7	...	6	...	...	7	5	...	2	...	...	...	...	...	...	...	...	34	17	1	15	1	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	3	3	...	...	...	...
...	...	...	6	1	...	5	...	...	2	2	...	...	...	...	11	7	...	4	...	...	3	2	...	1	...	...	...	...	...	...	...	...	22	12	...	10	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	...	...
...	...	...	8	6	1	1	...	...	5	3	...	2	...	...	15	12	...	2	1	...	16	9	...	7	...	...	2	...	2	...	...	...	47	31	3	12	1	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	1	...	...	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	3	...	...	...	...	...	...	...	...	...	...	3	3	...	...	...	...
...	...	...	42	12	4	24	1	1	4	2	...	2	...	...	11	6	...	4	1	...	14	6	4	4	...	...	1	1	...	...	...	...	73	28	8	34	2	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	1	...	1	...	...	...	3	2	1	...	...	...
...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	42	22	1	17	1	1	17	9	1	6	...	1	18	11	1	...	6	...	24	15	2	7	...	...	...	...	...	...	...	...	102	58	5	30	7	2
...	...	...	4	3	...	1	...	...	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	5	...	1	...	...
...	...	...	5	...	1	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...	1	4	...	...
...	...	...	...	...	...	...	...	...	4	3	...	1	...	...	3	3	...	...	...	...	2	1	...	...	1	...	...	...	...	...	...	...	9	7	...	1	1	...
...	...	...	21	9	4	7	1	...	5	3	...	2	...	...	5	4	...	...	1	...	4	4	...	...	...	...	...	...	...	...	...	...	35	20	4	9	2	...
...	...	...	11	9	...	2	...	...	1	1	...	...	...	...	1	1	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	14	12	...	2	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...	...	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...	...	4	1	...
...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...
...	...	...	14	6	1	7	...	...	7	4	...	3	...	...	8	5	...	3	...	...	19	14	1	4	...	...	1	1	...	...	...	...	51	32	2	17	...	...
...	...	...	10	7	...	3	...	...	...	...	...	...	...	...	4	1	...	3	...	...	8	3	2	3	...	...	...	...	...	...	...	...	22	11	2	9	...	...
...	...	...	4	3	...	1	...	...	...	...	...	...	...	...	5	3	...	1	1	...	7	5	1	1	...	...	...	...	...	...	...	...	17	12	1	3	1	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	3	1	1	...	...	1	2	...	1	1	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	7	3	2	1	...	1
...	...	...	4	4	...	...	...	...	3	2	...	1	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11	9	...	2	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
...	...	...	2	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	3	2	...	1	...	...
1	1	...	219	102	18	92	4	3	76	47	3	25	...	1	155	92	3	47	12	1	180	125	14	40	1	...	6	3	3	...	...	...	656	385	43	204	19	5

were the humerus, 7 times; the femur, 11 times; and the tibia and fibula, 11 times.

Of the 656 cases contained in the tables, 565 were males and 91 females. The youngest patient was thirteen and the oldest seventy years of age: the largest number was met with between twenty-eight and forty. In 61 of the cases the duration of the fractures was less than three months. The shortest period (a single case) reported was three weeks, the longest period ten years. The whole number cured by the various plans of treatment was 385. Of the remaining 271, 43 were relieved,—that is, the amount of motion in the ends of the bone was lessened,—in 204 no benefit was derived from the operations performed, 19 proved fatal, and in 5 the result was not ascertained.

In order to present in as compact and concise a manner as possible the practical deductions which may be drawn from so large an amount of detail, I shall place in tabular form a comparison of only those methods by which the largest number of cases of non-union of the most important bones were treated. The figures indicating these groups will be found to differ in some degree from those which appear in the general tables, but the discrepancy is only apparent, inasmuch as after omitting certain obsolete plans I have generalized those methods the action of which on the ununited bones is quite similar.

Non-Union of the Inferior Maxillary Bone.

No fracture is more difficult to keep at rest than that of the lower jaw. and it is a matter of surprise that non-union should not occur oftener than it does.

The whole number treated by all plans was 16. 13 were cured, 1 was relieved, and 2 died.

Methods.	No.	Cured.	Relieved.	Failed.	Died.	Unknown
Manual friction	...	...	...	...	...	...
Mechanical appliances	7	5	1	...	1	...
Seton	...	...	...	...	...	...
Immobilization	...	...	...	...	...	...
Resection, with its modifications	...	...	...	...	...	...
Drilling, with its modifications	7	7	...	...	...	...
Total	14	12	1	...	1	...

The mechanical appliances used consisted of external and interdental splints, and also of wiring together the teeth. This method, designed to secure the rest of the fragments, is practically immobilization. In drilling, the ends of the bone were in some instances only perforated, in other cases the drill was allowed to remain for some time in the fragments, and in other instances the pieces were wired together. After all these operations, it was necessary to apply a supporting dressing, like the Barton or the Gibson bandage. The result of the two plans of treatment adopted in non-union of the inferior maxillary is in favor of drilling, and by reference to the general table it will be seen that the preferable operation is that modification in which, after perforating the bone, the two ends are drawn together by wire.

Non-Union of the Humerus.

Two hundred and nineteen cases of ununited fracture of the humerus were treated by twenty-two different plans, with 102 cures, 18 relieved, 92 failures, 4 deaths, and 3 unknown.

Methods.	No.	Cured.	Relieved.	Failed.	Died.	Unknown
Manual friction	13	4	...	9	...	...
Mechanical appliances	10	6	3	1	...	...
Seton	42	12	4	24	1	1
Immobilization	13	5	1	6	1	...
Resection, with its modifications	83	43	6	31	2	1
Drilling, with its modifications	35	21	2	11	...	1
Total	196	91	16	82	4	3

The mechanical appliances employed were designed not to immobilize the fragments entirely, but to admit of slight friction. The modifications of resection consisted in boring into the bone a steel screw or gimlet, and in drilling and wiring together the ends of the bone, with or without a previous reflection of the periosteum. Forty-two of the 83 cases were treated by resection alone, with 22 recoveries, 1 relief, 17 failures, 1 death, and 1 without known result. The table above exhibits a success most favorable to resection with its modifications, and to drilling.

Non-Union of the Radius and Ulna.

The general table contains 37 cases of non-union of the radius and ulna, treated by fourteen different methods and their modifications. The result was 18 cures, 3 relieved, 15 failures, and 1 undetermined.

Methods.	No.	Cured.	Relieved.	Failed.	Died.	Unknown
Manual friction	4	1	...	3	...	...
Mechanical appliances	3	2	...	1	...	...
Seton	1	1	...	...	...	...
Immobilization	1	...	...	1	...	...
Resection, with its modifications	17	11	1	5	...	...
Drilling, with its modifications	4	...	1	3	...	...
Total	30	15	2	13	...	...

It will appear from the above table that the largest success in the treatment of ununited fracture of both bones of the forearm was obtained by resecting and wiring the fragments together.

Non-Union of the Radius.

Twenty-three cases of ununited fracture of the radius are comprised in the general table, 17 of which are recorded as cures and 6 as failures.

Methods.	No.	Cured.	Relieved.	Failed.	Died.	Unknown
Manual friction	...	...	...	...	...	...
Mechanical appliances	2	1	...	1	...	...
Seton	3	1	...	2	...	...
Immobilization	...	...	...	...	...	...
Resection, with its modifications	9	7	...	2	...	...
Drilling, with its modifications	4	3	...	1	...	...
Total	18	12	...	6	...	...

In the above group of 18 cases, resection and drilling, with their modifications, furnish the largest percentage of cures.

Non-Union of the Ulna.

Sixteen instances of non-union of the ulna have been tabulated, with 11 cures, 4 failures, and 1 in which the termination was not given.

Methods.	No.	Cured.	Relieved.	Failed.	Died.	Unknown
Manual friction	3	2	...	1	...	...
Mechanical appliances	1	1	...	...	...	...
Seton	...	...	...	...	...	...
Immobilization	...	...	...	...	...	...
Resection, with its modifications	3	...	...	2	...	1
Drilling, with its modifications	6	5	...	1	...	...
Total	13	8	...	4	...	1

The superiority of drilling over resection appears in the above comparison.

Non-Union of the Femur.

One hundred and fifty-five cases of ununited fracture of the femur appear in the general table, with 92 cures, 3 partial cures, 47 failures, 12 deaths, and 1 unknown.

Methods.	No.	Cured.	Relieved.	Failed.	Died.	Unknown
Manual friction	17	7	...	10	...	...
Mechanical appliances	29	22	2	4	1	...
Seton	11	6	...	4	1	...
Immobilization	24	14	...	10	...	...
Resection, with its modifications	32	19	1	4	8	...
Drilling, with its modifications	18	9	...	8	1	...
Total	131	77	3	40	11	...

Of the 29 cases treated by mechanical appliances, 14 used instruments which enabled them to walk about, 10 of whom were cured. The fatality which appears to have followed resection is sufficient to condemn this operation, and although the table exhibits only one death after the use of the seton, I am cognizant of others which have never been placed on record, and which are quite sufficient to subject this method also to condemnation. The success which has followed the use of a walking-apparatus, such as that of Professor Smith, the employment of which involves no risk whatever to the life of the patient, is a sufficient reason why this mechanism should take precedence of all other plans of treatment; and in the event of its failure to induce consolidation of the bone, the subcutaneous drill or gimlet should be next employed.

Non-Union of the Tibia and Fibula.

The whole number of cases of non-union of the tibia and fibula comprised in the general table is 94, 71 of which were cured, 3 were relieved, 19 failed, and 1 died.

Methods.	No.	Cured.	Relieved.	Failed.	Died.	Unknown
Manual friction	10	7	1	2	...	...
Mechanical appliances	15	11	...	4	...	...
Seton	4	3	...	1	...	...
Immobilization	11	8	...	3	...	...
Resection, with its modifications	20	13	1	5	1	...
Drilling, with its modifications	10	8	1	1	...	...
Total	70	50	3	16	1	...

The entire safety of mechanical appliances and of immobility, and the success which has attended their use, are reasons sufficiently cogent for their adoption in preference to other measures in the treatment of ununited fractures of the bones of the leg: in the event of these failing to insure union, subcutaneous drilling should be next selected.

Non-Union of the Tibia.

The whole number treated was 84, with the following result: 52 were cured, 11 were relieved, and 21 died.

Methods.	No.	Cured.	Relieved.	Failed.	Died.	Unknown
Manual friction	4	2	2	...	...	...
Mechanical appliances	11	7	...	4	...	...
Seton	10	3	4	3	...	...
Immobilization	...	...	...	...	...	...
Resection, with its modifications	14	11	1	2	...	...
Drilling, with its modifications	25	15	3	7	...	...
Total	64	38	10	16	...	...

Of the 11 cases treated by mechanical appliances, 5 wore walking-splints, all of whom were cured. When resection is deemed proper, it will enhance the prospects of success, in case any considerable portion of the ends of the tibia is removed, either to fracture or to excise a part of the fibula, in order to admit of the contact of the ends of the former bone.

Non-Union of the Fibula.

Two cases were treated,—the one by friction, and the other by subcutaneous drilling; both with a successful result.

Non-Union of the Patella.

Six cases were treated,—1 by counter-irritation, 2 by retentive apparatus, 1 by seton (the thread being placed not between, but alongside of the bone), 1 by a subcutaneous section of a part of the quadriceps, with a view to bring the upper piece down, and 1 by drilling and wiring together the two fragments. The result of these different plans of treatment was 3 cures and 3 improved. The object aimed at in the treatment of these instances of non-union was doubtless to obtain a close ligamentous connection of the fragments.

Summary.

In summing up the whole number treated by the six methods which I have placed in comparison, we have 544 cases of non-union, with 300 cures and 17 deaths, distributed as follows:

Methods.	No.	Cures.	Deaths.
Manual friction	53	25	...
Mechanical appliances	80	57	2
Seton	73	27	2
Immobilization	49	27	1
Resection, with its modifications	178	104	11
Drilling, with its modifications	111	60	1
Total	544	300	17

Eight of the 17 fatal cases occurred after resection and drilling of the ends of the bone in ununited fractures of the femur.

After a careful analysis of the material at hand, and from the results of my own observation and experience, I think the following rules embody the best guides for dealing practically with this subject:

1. In the treatment of an ununited fracture of any bone, always begin with the simplest and the least dangerous of those measures which have ordinarily proved most successful, and advance, if necessary, to those the employment of which involves greater danger. In conformity with this rule, forcible manual friction, conjoined with immobilization, should precede all other plans, especially in recent forms of non-union. Next in order would come the use of mechanical appliances or apparatus, by which passive friction at the ends of the bone can be maintained. Following manual and instrumental friction, the use of the subcutaneous drill and its modifications will be next indicated; and last, resection, with its various modifications.

2. In ununited fracture of the femur, the dangers attending either the employment of the seton or a resort to resection are so great, that these methods should be entirely discarded from the surgical resources applicable to the condition under consideration.

3. In instances of ununited fracture where it is deemed proper to employ the seton, the latter should not be allowed to remain longer than from seven to ten days.

Deformed or Vicious Union.

Union of a fracture may take place in such a manner as to impair the usefulness of the limb, and sometimes to occasion marked deformity. The causes which conduce to these results are insubordination on the part of the patient, refusal to submit implicitly to the instructions of his professional attendant, carelessness or want of skill in adjusting and dressing the fracture, and a choreic state of the muscles of the limb. Deformity may also unavoidably follow compound fractures accompanied with severe and extensive contusion of the soft parts, in consequence of which it had been impossible to make the necessary extension or compression; and, finally, a vicious union may result from a patient's being unable to secure the necessary surgical attendance.

The deformity may consist in overlapping of the fragments, producing shortening of the limb (Fig. 611); in angular union of the bone (Fig. 612); and in rotation of the distal end of the fracture upon its axis (Fig. 613).

Shortening and Rotatory Displacement.—In case of overlapping, the course of the surgeon must be determined by the amount of shortening present,

Fig. 611.

Overlapping of the ends of a broken bone, causing marked shortening.

Fig. 612.

Angular union of a fracture at the upper part of the femur.

Fig. 613.

Lower fragment of the femur rotated outwards.

the time which has elapsed since the injury to the bone affected, and the degree of disability imposed by the deformity. Some shortening may be expected to follow most fractures, and is in no way inconsistent with a good cure. In the case of the femur, when the overlapping does not exceed two inches, and when the union is solid, an operation for its correction is not necessary. When, however, the callus is soft, and the fragments are found to be movable, the bone should be refractured, and the necessary extension applied to restore the limb to its proper length. In consequence of the varying progress of ossification in different persons, such a course in one person may not be feasible at the end of five weeks, and in another may be practicable after a much longer time. When the overlapping follows a fracture of the humerus, unless, in some way, the usefulness of the arm is seriously impaired, it had better be left without interference, however much shortening is present, as the advantage resulting from its recalcification will scarcely compensate for the inconveniences attending the refracture.

Angular Union.—Where the displacement is angular, even though the consolidation has become complete, it is of the utmost importance that the deformity should be corrected. In some situations the evils of such a union increase with the lapse of time. Thus, in badly-treated fractures of the lower end of one or both bones of the leg, followed by eversion of the foot, the deformity will become greater and the disability increase daily under the superincumbent weight of the body.

In case of fractures viciously united, and not older than three or four weeks, it is possible to correct the deviation from the proper line at once by exhibiting an anæsthetic and then straightening the part over the knee placed against the summit of the curve. This may be done in some instances without disconnecting the fragments, the callus being sufficiently soft to admit of the correction without an actual rupture. Fig. 614 gives an illustration of a deformity following a fracture of the bones of the forearm, which I was able to remedy in this manner after the lapse of five weeks (Fig. 615).

In older cases, where the consolidation is too firm to admit of being treated in the above manner, resort may be had to mechanical contrivances in

FIG. 614.

Deformed union of the radius and ulna.

FIG. 615.

The same corrected instantaneously, without refracture, by bending the part over the knee.

order to apply continuous pressure. The construction of some of these mechanisms demands considerable skill, but for the most part the appliances are so simple that the surgeon who possesses any handicraft whatever can prepare them for himself. In many of those cases of vicious union which are met with in the arm and the leg, nothing is required save a straight, well-padded splint, compresses, and two or three roller bandages. The dressing can be placed on either aspect of the curve, or may be changed from one to the other. Figs. 616 and 617 will serve to illustrate the plans of employing pressure for the purpose of correcting curved or angular deformity.

FIG. 616.

Splint placed on the concave side of a curve, and bound to the part by the turns of a roller.

FIG. 617.

Splint placed on the convex side of a curve, and bound to the extremities of the part.

The result of steady persistence in such a method will soon be apparent in the gradual improvement of the deviation, even where it has existed for two or three months.

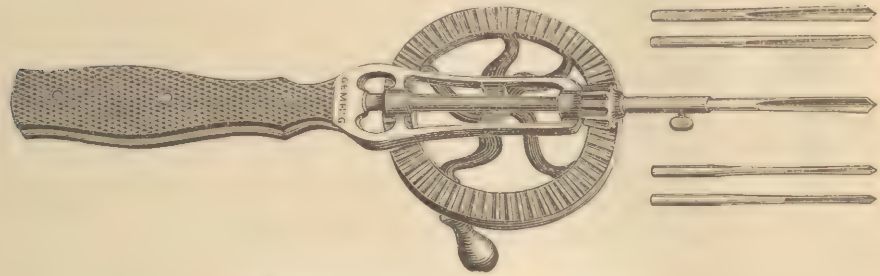
Where the union is so firm that neither extension nor compression nor both combined make any impression. something more decided must be done, either by acting on the callus in such a manner as to induce *softening*, or by *refracturing* the bone by the application of a sufficient force.

To accomplish the first, a small puncture may be made in the soft part with a sharp-pointed bistoury, through which a drill can be carried down

upon the seat of fracture and made to penetrate the callus by a rotatory movement in different directions.

By means of the drill represented in Fig. 618 the perforation of the callus can be effected in a few moments.

FIG. 618.



Bone-drill geared so as to revolve with great rapidity.

In old cases of angular deformity a subcutaneous section of the bone can be effected without difficulty by means of the Adams saw (Fig. 619), an opening being made for the instrument by a long, narrow, sharp-pointed bistoury.

FIG. 619.

Adams saw for subcutaneous division of the thigh-bone.

On the removal of the instrument, the minute wound in the soft parts should be closed with a strip of adhesive plaster, and the limb placed at rest. After the lapse of seven or eight days the inflammatory action excited in the callus will have produced such a degree of softening as to render feasible the correction of the deformity by graduated pressure applied on the principle already described, and at this time the dressing for that purpose may be adjusted.

If refracture be determined upon, it may be done by placing the knee, as a point for counter-pressure, against the seat of deformity, and, after grasping the limb above and below, applying the necessary force; or it may be accomplished by bending the part over the edge of a table. When the callus is so firm as to offer great resistance, it may be first weakened by the drill, and then broken at once, after which it should be placed in the proper position, and so retained by appropriate dressings. A difficulty is sometimes encountered in the shortening of the muscles, so that, even after the refracture, the limb cannot be brought into a straight position without great overlapping: such a complication is most likely to be met with in the thigh or in the leg. A steady, constant extension, by a sufficient weight attached to the limb, will elongate the muscles to a moderate degree, and this, together with the division of such tendons as oppose the adjustment, will generally render the correction feasible. If the various means described prove inadequate or inappropriate, there is nothing left but to excise the ends of the bone or the projecting angle by a V-shaped cut. This, of course, involves a compound fracture, and is environed with so many dangers that it is only to be under-

taken when no other course is practicable. The deformity resulting from rotatory displacement is to be corrected, where extreme, by the same procedure as that adopted for angular union.

The union of adjacent bones by a bridge of callus is productive of very little inconvenience when it takes place between adjoining ribs, or between the tibia and the fibula, but when it involves the radius and the ulna, as in Fig. 620, it destroys two very important movements of the hand, those of pronation and supination, and an effort should be made to break the bond by forcibly pronating and supinating the hand. Malgaigne records a single case, that of Gardiel, in which the separation was effected by cutting down upon the callus and rupturing it, an operation which, in so important a member as the arm, I would not recommend: when an operation is necessary, the callus should be drilled from the back of the arm and afterwards ruptured.

FIG. 620.

Radius and ulna blended by callus after a fracture of both bones.

The questions which naturally arise in connection with this subject are the following:

1. Does not refracture expose the patient to the risk of inflammation and abscess? If produced by force alone, they are not more likely to follow than after the first accident: if the drill is employed, the dangers of inflammation are increased.

2. Is there not danger that by interrupting the process of consolidation, or by making a different disposition of the fragments, reunion may be prevented? The answer is, that in many cases of accidental and intentional refracture the reparation has gone on with even more rapid progress than after the first injury. I am sure this has been my hospital experience.

3. Is there not danger of breaking the bone at some other point than through the original fracture? This is exceedingly improbable. There is a popular notion that the strongest part of the bone is at the seat of union. This is not supported by observation. I have seen cases in which the same bone had been broken twice at the same point, the accidents occurring over one year apart.

4. In resection may not the gap be too great to be bridged by bone? This is possible. Such cases have occurred, though they are exceedingly rare. The interval which is made by excision is generally diminished by the subsequent shortening of the muscles.

With this enumeration of the various resources which we have at command to correct deformed union, the surgeon may still be at a loss to know what course to adopt or which should receive the preference. Let me, then, lay down a few rules for his conduct:

1. Where the deformity is out of sight, and does not materially interfere with the use of the limb, let it alone. If the deformity consists in mere irregularities or salient points, nothing need be done. The vessels of the part will round these away.

2. If seen at a time when the callus is not compact, but pliable, and if pressure is practicable, an effort should be made to diminish or remove the deformity by gradual pressure.

3. If the case has passed beyond this period, refracture by force judiciously applied over the knee or a table.

4. If foiled in this, resort to subcutaneous drilling in order to weaken the callus, so that it can be broken; or, if the case is one of long standing, and in a single bone, like the humerus or the femur, a subcutaneous section by the saw will be the simplest plan of correcting the evil.

5. As a last resort, excision may be employed; but it should be undertaken only in cases where the deformity involves great disability, and when other methods are impracticable.

Morbid Changes of Callus.

Callus undergoes various changes, depending sometimes upon local and at other times upon constitutional causes. Among these may be enumerated its appearance on portions of the bone some distance from a fracture. It would appear from this that the nutrition of a broken bone may be so modified that an unusual activity of the periosteum may be excited at points distant from the injury, producing spines or stalactitic formations.

Great redundancy of callus (Fig. 621) is frequently met with. Such will generally be the case where the fragments have been subjected to much disturbance, or where there is great overlapping. In the first the excess is the result of irritation; in the second, of an extraordinary necessity. In cases where necrosis takes place after a fracture, a great excess of new bone will be formed, sometimes traversed by numerous openings, and often incarcerating the dead portions. This condition will be met with in compound and in comminuted fractures.

FIG. 621.

Redundant callus about a united fracture of the femur with overlapping.

The same excessive formation of callus is frequently witnessed after gunshot fractures. This is especially noticeable when the bone is both broken and fissured. In such cases nature makes unusual attempts to bind together the severed pieces; the periosteum is stimulated to great activity, even at points quite remote from the injury, and, in consequence of this, shapeless masses of disorderly arranged ossific matter rise from the bone, often sending long spines into the midst of the overlying soft parts. (Fig. 622.)

Callus may undergo *absorption*. This constitutes one of the causes of false joint. This may result from premature movement, long-continued anodyne lotions, or such an amount of compression by bandages as interferes with the easy transit of blood through the venous and arterial trunks of the part. Generally there is a constitutional cause at work to effect its removal. Very recently I saw a case in which a fracture of the thigh of six weeks' standing, and which had become quite solid, lost its callus and again became movable. The cause was doubtless due to a low febrile condition, with mental aberration, referable to chronic alcoholism. As the patient improved, reunion again took place. Mercurial ptyalism occurring in the course of repair, there is reason to believe, may not only arrest the growth of the callus,

FIG. 622.

Exuberant callus following a gunshot wound of the upper third of the femur.—Army Medical Museum.

but also cause the absorption of what has been already formed. So also any cause, either therapeutic or dietetic, which destroys the proper consti-

tution of the blood and renders it unfit for the food of the tissues, may favor the same result. One of the most remarkable of the various effects of scurvy on the crew accompanying Lord Anson was the dissolution of the union of old fractures.

In order to treat such cases a careful inquiry must be instituted to determine the cause. If the patient is deficient in vigor, mineral tonics should be administered, with improved diet, including a free use of vegetables; if a scorbutic condition is suspected, all bandages or splints which unduly constrict or press the limb should be removed, and brisk friction with stimulating liniments be employed.

Brittleness forms another disease of callus, in which there is a defect in the proper relation between the animal and the saline constituents of the bone, the latter being in excess. For its explanation we must invoke a constitutional state,—a cachexia, induced by cancer, syphilis, etc. In those persons who suffer from fragility of the skeleton, exposing them to fractures on the reception of the most trivial injury, the callus following will partake of the same vice. I know of no remedy for such a condition but good diet, fresh air, and extraordinary care.

Sensitive callus.—As we frequently have painful cicatrices in the soft parts, so callus, which is the cicatrix of bone, may be the seat of great suffering, in consequence of undue pressure upon an adjacent nerve-trunk.

When the pressure upon a nerve is great, there may follow not only weakness, but even complete paralysis, in the group of muscles supplied by its branches. Such effects are witnessed in the wrist-drop which occasionally follows fracture of the humerus near the point where the musculo-spiral nerve winds round the bone; also in the loss of the power of flexing and abducting the foot sometimes witnessed after fracture of the upper part of the fibula. (Fig. 623.)

Fig. 623.

Foot-drop from pressure by callus on the peroneal nerve after fracture of the upper part of the fibula.

We should distinguish between that painful condition of a limb which follows a restored fracture, and which is so often modified by changes in the weather, and that pain which is localized in the callus itself. The first seems to be of a rheumatic nature, and will often yield to anti-rheumatic remedies, such as the iodide of potash, colchicum, or electro-galvanism. I have seen a painful state of the limb so severe as to lay the patients aside for months follow fractures of the fibula after the fragments were consolidated.

The suffering which is sometimes experienced when the callus is exuberant is due in part to the congestion of the surrounding soft parts, and is often accompanied with a change in their color and temperature. The ancients recognized such conditions, and devoted much time to their treatment. The tendency, of course, when the union is firm, is to absorption of the redundant mass, and we may therefore be content with stimulating and anodyne lotions. If the distress continues persistent, successive blisters will often be found to have the happiest effect. Should these fail, and the callus remain undiminished, the mass may be drilled, in order to favor its absorption.

Sometimes when the callus is very voluminous there will be found in it a central cavity, perhaps associated with a fracture imperfectly united. Such cases are furnished by Guyot.* These, if the suffering is great, should be treated by transfixion with the gimlet, and by rest, as described under the head of ununited fractures.

* Archives de Médecine, February, 1836.

Table of Fractures treated at the Pennsylvania Hospital.

The late Dr. Norris tabulated the fractures treated in the Pennsylvania Hospital during twenty years,—from 1830 to 1850,—making an aggregate of 2182. Of this number, 1726 were cured, 179 were relieved or were removed by friends, and 303 died. The relative frequency of these injuries will be seen in the table containing the general summary. Taking up the subject where Dr. Norris left it, Dr. De Forrest Willard, with the assistance of Dr. R. H. Alison, has collected and arranged, as exhaustively as the records allowed, all fractures received and treated in that institution down to 1874.

The following table contains an aggregate of 6485 fractures, not including those of Norris. Of this number, 4950 were cured, 393 relieved, 249 unknown, and 893 died. So far as noted, 5128 were males and 1043 females; 2122 were recorded as occurring on the right side, and 2231 on the left. The nature of the fractures was as follows: 4932 were simple, 213 were simple comminuted, 792 were compound, 532 were compound comminuted, and 16 were undetermined. The largest number of fractures—1464—occurred between the ages of twenty and thirty; the next largest number—1300—between thirty and forty. The most material deviation from these ages existed in reference to fracture of the ribs,—57 out of the 221 injuries of this kind having taken place between forty and fifty. This exception to the general rule will be readily explained by the ossification in the cartilaginous connection of the costal arches with the sternum, which exists at this time of life, and which, from the loss of elasticity, necessarily renders them less able to resist injury.

The fatality following fractures of the skull is very noticeable among the figures in the table. Of 195 instances of this injury, 79 died, or 40 per cent. In 16 cases the trephine was used, of which number 8 died. Dr. Norris's collection embraced 110 cases of skull fractures, with 67 deaths, a mortality of 41 per cent.

If to the 6485 cases of Willard there be added the 2182 of Norris, we have an aggregate of 8667 fractures, with 6676 cures, 1196 deaths, and 815 cases in which the result was undetermined.

The relative frequency of these fractures in different portions of the skeleton is as follows:

	Willard.	Norris.	Total.		Willard.	Norris.	Total.
Tibia and fibula	1074	367	1441	Hand	143	69	212
Femur	885	296	1181	Foot	120	52	172
Radius	777	208	985	Patella	106	42	148
Humerus	765	203	968	Pelvis	80	14	94
Clavicle	508	188	696	Scapula	54	28	82
Radius and ulna	477	122	599	Vertebræ	48	25	73
Tibia	315	122	437	Nose	30	23	53
Fibula	315	122	437	Superior maxilla	24	.....	24
Ribs	221	88	309	Face	10	.....	10
Cranium	195	110	305	Sternum	7	6	13
Ulna	172	46	218	Hyoid	1	.....	1
Inferior maxilla	158	51	209				

Taking the bones of different regions collectively, the relative proportion of fractures is as follows: lower extremity, 45 per cent.; upper extremity, 44 per cent.; head, 6 per cent.; trunk, 5 per cent.

Table of Fractures treated at the Pennsylvania

(Abbreviations.—S., simple. S.C., simple, comminuted. C.,

Bone.	Form.	Position.	Age.	Sex.	Side.	Result.
Cranium....... 195	S....... 39	Frontal.................................. 59	Under 10 yrs... 23	M.. 178	R...... 49	Deaths............ 79
	S.C.... 10	Frontal and parietal............ 5	From 10 to 20. 33	F... 17	L...... 56	
	C 89	Front., ethmoid, and sphenoid 1	“ 20 “ 30. 59	—	U...... 90	
	C.C.... 57	Parietal 37	“ 30 “ 40. 35	195	—	
	—	Parietal and temporal.......... 2	“ 40 “ 50. 21		195	
	195	Temporal............................ 18	“ 50 “ 60. 13			
		Temporal and frontal........... 2	“ 60 “ 70. 9			
		Occipital............................ 4	“ 70 “ 80. 2			
		Occipital and parietal........... 3	—			
		Occipital, parietal, and temp.. 1	195			
		“Base”.............................. 13				
		“Skull”............................. 50				
		—				
		195				
Nasal........... 30	S. 10		Under 10 yrs... 5	M.. 27	R...... 3	Cured................ 27
	S.C..... 4		From 10 to 20. 5	F... 3	L...... 7	Relieved........... 3
	C 12		“ 20 “ 30. 13	—	U...... 9	—
	C.C..... 4		“ 30 “ 40. 7	30	Both.. 11	30
	—		—		—	
	30		30		30	
“Face”......... 5	....	Bone not given.			R...... 3	Cured................ 3
					L...... 2	Unknown.......... 2
					—	—
					5	5
Zygoma......... 1	S....... 1	Parietal also fractured.	From 20 to 30. 1	M.. 5	Both.. 1	Died................. 1
Malar............ 4	C....... 2		“ 30 “ 40. 3		U...... 4	Cured................ 4
—	C.C.... 2		“ 70 “ 80. 1		—	—
5	—		—		5	5
	5		5			
Sup. maxilla... 24	S....... 5	Alveolar process.................. 6	Under 10 yrs... 5	M.. 21	R...... 5	Cured................ 19
	C....... 9	Unrecorded......................... 18	From 10 to 20. 1	F... 3	L...... 5	Died.................. 5
	C.C.... 10	—	“ 20 “ 30. 6	—	U...... 14	—
	—	24	“ 30 “ 40. 8	24	—	24
	24		“ 40 “ 50. 4		24	
			—			
			24			
Inf. maxilla... 158	S....... 74	Symphysis......................... 44	Under 10 yrs... 5	M.. 147	R...... 50	Relieved and
	S.C.... 7	Body................................. 25	From 10 to 20. 27	F... 11	L...... 34	cured............ 150
	C....... 58	Angle................................ 24	“ 20 “ 30. 66	—	Centre 44	Deaths............ 8
	C.C.... 19	Alveolus............................ 2	“ 30 “ 40. 36	158	U...... 30	—
	—	Ramus............................... 7	“ 40 “ 50. 17		—	158
	158	Condyles........................... 2	“ 50 “ 60. 6		158	
		Unrecorded........................ 54	“ 60 “ 70. 1			
		—	—			
		158	158			
Hyoid........... 1	S....... 1	....	....	....	....	....
Vertebræ...... 48	S....... 46	Cervical region :	From 10 to 20. 5	M.. 46	....	Deaths in hospital 27
	C.C.... 2	2d and 3d..................... 1	“ 20 “ 30. 17	F... 2	....	
	—	2d cerv. and 1st dorsal... 1	“ 30 “ 40. 13	—		
	48	4th............................. 3	“ 40 “ 50. 9	48		
		6th............................. 2	“ 50 “ 60. 3			
		1st, 5th, and 6th........... 1	“ 60 “ 70. 1			
		4th, 5th, and 6th........... 1	—			
		5th and 6th.................. 1 10	48			
		Dorsal :				
		2d, 4th, 5th, and 12th..... 1				
		5th............................. 1				
		5th and 6th.................. 1				
		7th 1				
		9th, 10th, and 11th........ 1				
		10th........................... 1				
		11th and 12th.............. 1				
		12th 5				
		Unrecorded.................. 4 16				
		Lumbar :				
		1st............................. 1				
		2d.............................. 1				
		1st and 2d................... 1				
		Unrecorded.................. 3 6				
		Sacrum................................ 2				
		Unrecorded......................... 14				
		—				
		48				
Sternum....... 7	S....... 7	Manubrium......................... 1	From 20 to 30. 3	M.. 7	....	Deaths........ 2
		Manubrium and gladiolus..... 4	“ 30 “ 40. 2			
		Body................................. 2	“ 60 “ 70. 2			
		—	—			
		7	7			

Hospital from January 1, 1850, *to January* 1, 1874.

compound. C.C., compound, comminuted. U., unrecorded.)

Trephining.	Deaths after trephining.	Other deaths, causes of.	Principal occupations.
C.C. 11	C.C. 8	Compression (C.C., 7; C., 10; S.C., 3; S., 7) 27	Laborers 50
C. 4	Cause:	"Injuries" (C.C., 6; C., 3; S.C., 1; S., 4) 14	Seamen 10
S. 1	Cerebritis 2	Meningitis (C.C., 7; C., 2) 9	School-children 10
	Meningitis 1	Abscess (C.C., 4; C., 1; S., 1) 6	Carpenters 9
	Unrecorded 5	Shock (C., 2; S.C., 1; S., 2) 5	Drivers 7
		Exhaustion (C.C., 1; C., 2; S., 1) 4	Masons 5
		Hernia cerebri (C.C., 3) 3	Railroad-men 5
		Hemorrhage (C., 2) 2	Miners 4
		Erysipelas (C., 1) 1	Factory-hands 6
		—	Errand-boys 4
		(C.C., 28; C., 23; S.C., 5; S., 15) 71	
		None	Laborers 11
			Drivers 4
			Hostlers 2
	None		
	Died after trephining 1		Laborers 5
		Mania a potu (C.C., 1; C., 1) 2	Laborers 4
		Exhaustion 3	Drivers 2
		—	Railroad-men 2
		5	
		Mania a potu 2	Laborers 45
		Tetanus 1	Drivers 8
		Shock 2	Seamen 7
		Pyæmia 1	Servants 7
		Œdema of glottis 1	Railroad-men 5
		Pneumonia 1	Hostlers 5
		—	Boatmen 4
		8	Miners 4
		"Injuries" 3	Laborers 17
		Shock 3	Drivers 3
		Exhaustion 4	Seamen 2
		Compression 2	Miners 2
		Suffocation 2	Firemen 2
		Unrecorded 13	Carpenters 2
		—	
		27	
		Apoplexy 1	Laborers 4
		Unrecorded 1	Boatman 1
		—	Plumber 1
		2	

Table of Fractures treated at the Pennsylvania

Bone.	Form.	Position.	Age.	Sex.	Side.	Result.
Ribs............ 221	S...... 212	1st to 12th.............. 1	Under 10 yrs... 3	M.. 196	R..... 71	Deaths.............. 24
	S.C... 8	1st and 3d.............. 1	From 10 to 20. 11	F... 25	L..... 66	
	C...... 1	1st and 4th.............. 1	" 20 " 30. 36	—	U..... 84	
	—	2d and 3d.............. 1	" 30 " 40. 50	221	—	
	221	2d, 3d, 4th, 5th, 6th, 7th...... 1	" 40 " 50. 57		221	
		2d.............. 1	" 50 " 60. 36			
		2d, 3d, 4th.............. 2	" 60 " 70. 21			
		3d.............. 3	" 70 " 80. 6			
		3d, 4th, 5th.............. 3	" 80 " 0. 91			
		3d, 4th, 5th, 6th.............. 1	—			
		3d and 4th.............. 1	221			
		4th.............. 5				
		4th and 5th.............. 2				
		4th, 5th, 6th.............. 1				
		4th, 5th, 6th, 7th, 8th.......... 2				
		5th.............. 2				
		5th and 6th.............. 6				
		5th, 6th, 7th, 8th.............. 2				
		5th, 6th, 7th.............. 3				
		5th, 6th, 7th, 8th, 9th, 10th.. 1				
		6th.............. 3				
		6th and 7th.............. 4				
		6th, 7th, 8th.............. 6				
		6th, 7th, 8th, 9th.............. 4				
		7th.............. 4				
		7th and 8th.............. 4				
		7th, 8th, 9th.............. 7				
		7th, 8th, 9th, 10th.............. 2				
		8th.............. 5				
		8th and 9th.............. 4				
		8th and 11th.............. 1				
		8th, 9th, 10th.............. 5				
		9th.............. 7				
		9th and 10th.............. 3				
		9th, 10th, 11th.............. 1				
		10th.............. 3				
		10th and 11th.............. 3				
		10th, 11th, 12th.............. 1				
		11th.............. 4				
		12th.............. 4				
		Costal cartilage.............. 1				
		Unrecorded.............. 105				
		—				
		221				
Clavicle........ 508	S...... 470	Outer third.............. 178	Under 10 yrs... 45	M.. 422	R..... 163	Cured.............. 447
	S.C... 28	Middle third.............. 179	From 10 to 20. 84	F... 86	L..... 203	Relieved.......... 52
	C..... 8	Inner third.............. 16	" 20 " 30. 146	—	U..... 142	Died.............. 9
	C.C... 2	Unrecorded.............. 135	" 30 " 40. 94	508	—	—
	—	—	" 40 " 50. 72		508	508
	508	508	" 50 " 60. 43			
			" 60 " 70. 10			
			" 70 " 80. 12			
			" 80 " 90. 1			
			" 90 " 100. 1			
			—			
			508			
Scapula........ 54	S...... 49	Body.............. 9	Under 10 yrs.. 2	M.. 48	R..... 19	Cured.............. 45
	S.C... 2	Acromion.............. 12	From 10 to 20. 4	F... 6	L..... 20	Relieved.......... 6
	C..... 2	Spine.............. 10	" 20 " 30. 14	—	U..... 15	Died.............. 3
	C.C... 1	Inferior angle.............. 4	" 30 " 40. 10	54	—	—
	—	Superior angle.............. 1	" 40 " 50. 15		54	54
	54	Neck.............. 5	" 50 " 60. 5			
		Glenoid.............. 1	" 60 " 70. 3			
		Coracoid.............. 1	" 70 " 80. 1			
		Unrecorded.............. 11	—			
		—	54			
		54				
Humerus...... 765	S...... 620	Anatomical neck.......... 22	Under 10 yrs.. 118	M.. 657	R..... 255	Cured.............. 647
	S.C... 36	Surgical neck.............. 42	From 10 to 20. 219	F... 108	L..... 286	Relieved.......... 83
	C..... 61	"Neck".............. 49	" 20 " 30. 136	—	U..... 224	Died.............. 35
	C.C... 48	"Head".............. 14	" 30 " 40. 98	765	—	—
	—	Upper epiphysis.............. 1	" 40 " 50. 63		765	765
	765	"Upper portion".......... 80 208	" 50 " 60. 73			
		Middle third.............. 133	" 60 " 70. 35			
		Condyle.............. 81	" 70 " 80. 18			
		Inner condyle.............. 76	" 80 " 90. 5			
		Outer " 40	—			
		Epiphysis.............. 6	765			
		"Lower third".............. 97 300				
		Unrecorded.............. 124				
		—				
		765				

Hospital from January 1, 1850, *to January* 1, 1874.

Amputations.	Deaths after amputation.	Other deaths, causes of.	Principal occupations.
		Shock 5 Mania a potu 2 Pyæmia 2 Peritonitis 2 Hemorrhage 1 Injury to lung 2 Pneumothorax 1 Empyema 1 Unrecorded 8 — 24	Laborers 69 Housewives 17 Drivers 9 Carpenters 7 Seamen 6 Peddlers 5 Masons 4 Miners 4 Boatmen 3
Exsection for gunshot injury, compound 1 Recovered 1		Injuries (S.C., 1; S., 2) 3 Mania a potu (S.C., 1) 1 Pleuro-pneumonia (C.C., 1) 1 Compression of brain (S., 1) 1 Pyæmia (C., 1) 1 Old age (C., 1) 1 Unrecorded (S., 1) 1 — (C.C., 1; C., 2; S.C., 2; S., 4) 9	Laborers 152 School-children 49 Young children 15 Errand-boys 3 Housewives 43 Drivers 16 Factory-hands 14 Seamen 14 Shoemakers 7 Machinists 5
		Gunshot injuries (C.C., 1) 1 Shock (S., 1) 1 Unrecorded (S., 1) 1 — (C.C., 1; S., 2) 3	Laborers 20 Factory-hands 2 Drivers 2 Sewing-women 2
C.C. 25 C. 12 S.C. 1 38 Resection 4 Died 1	Shock (C.C., 3; C., 1) 4 Pyæmia (C.C., 3) 3 Exhaustion (C.C., 3) 3 Secondary hemorrhage (C., 1) 1 — (C.C., 9; C., 2) 11	Shock (C.C., 4; C., 2) 6 Injuries (C.C., 1; C., 2; S., 1) 4 Exhaustion (C.C., 2; S., 2) 4 Pyæmia (C., 1; S.C., 1) 2 Gangrene (C.C., 1; S., 1) 2 Secondary hemorrhage (C., 1) 1 Concussion (S., 1) 1 Apoplexy (S., 1) 1 Old age (S., 1) 1 Unrecorded (C.C., 1; S., 1) 2 — (C.C., 9; C., 6; S.C., 1; S., 8) 24	Laborers 125 School-children 126 Small children 27 Housewives 45 Factory-hands 27 Drivers 23 Carpenters 23 Seamen 13 Errand-boys 13

Table of Fractures treated at the Pennsylvania

Bone.	Form.	Position.	Age.	Sex.	Side.	Result.
Radius......... 777	S...... 733	Upper third.......... 24	Under 10 yrs.. 33	M.. 477	R..... 278	Cured.......... 703
	S.C... 6	Middle third.......... 53	From 10 to 20. 153	F... 300	L..... 264	Relieved.......... 66
	C..... 21	Lower third, including	" 20 " 30. 143	—	U..... 235	Died.......... 8
	C.C... 10	"Barton's"........ 230	" 30 " 40. 150	777	—	—
	U..... 7	"Colles'"........ 141	" 40 " 50. 125		777	777
	—	"Smith's"........ 14	" 50 " 60. 106			
	777	"Lower portion"...... 186 571	" 60 " 70. 40			
		Unrecorded.......... 129	" 70 " 80. 16			
		—	" 80 " 90. 2			
		777	Unrecorded... 9			
			—			
			777			
Ulna......... 172	S...... 124	Upper third, including	Under 10 yrs.. 18	M.. 148	R..... 74	Cured.......... 153
	S.C... 4	Olecranon........ 52	From 10 to 20. 34	F... 24	L..... 59	Relieved.......... 16
	C. ... 34	Coronoid........ 3	" 20 " 30. 43	—	U..... 39	Died.......... 3
	C.C... 10	"Upper"........ 27 82	" 30 " 40. 27	172	—	—
	—	Middle third.......... 32	" 40 " 50. 24		172	172
	172	Lower third.......... 29	" 50 " 60. 14			
		Unrecorded.......... 29	" 60 " 70. 7			
		—	" 70 " 80. 2			
		172	Unrecorded... 3			
			—			
			172			
Radius and ulna......... 477	S...... 357	Upper third.......... 39	Under 10 yrs.. 53	M.. 395	R..... 176	Cured.......... 408
	S.C... 5	Middle third.......... 147	From 10 to 20. 180	F... 82	L..... 154	Relieved.......... 44
	C..... 57	Lower third.......... 125	" 20 " 30. 99	—	U..... 147	Died.......... 25
	C.C... 54	Unrecorded.......... 166	" 30 " 40. 58	477	—	—
	U..... 4	—	" 40 " 50. 33		477	477
	—	477	" 50 " 60. 31			
	477		" 60 " 70. 7			
			" 70 " 80. 7			
			" 80 " 90. 3			
			Unrecorded... 6			
			—			
			477			
Hand......... 143	S...... 37	Carpus.......... 9	Under 10 yrs.. 2	M.. 137	R..... 22	Cured.......... 99
	S.C... 2	Metacarpus.......... 53	From 10 to 20. 43	F... 6	L..... 31	Relieved.......... 17
	C...... 75	Phalanges.......... 44	" 20 " 30. 50	—	U..... 90	Died.......... 8
	C.C... 29	Thumb.......... 17	" 30 " 40. 25	143	—	Unrecorded....... 19
	—	Unrecorded.......... 20	" 40 " 50. 14		143	—
	143	—	" 50 " 60. 7			143
		143	" 60 " 70. 2			
			—			
			143			
Pelvis......... 80	S...... 58	Ilium.......... 33	Under 10 yrs.. 3	M.. 76	R..... 24	Cured.......... 49
	S.C... 5	Acetabulum.......... 10	From 10 to 20. 9	F... 4	L..... 17	Died.......... 31
	C..... 4	Pubis.......... 5	" 20 " 30. 24	—	U..... 39	—
	C.C... 8	Ischium.......... 2	" 30 " 40. 11	80	—	80
	U..... 5	Unrecorded.......... 30	" 40 " 50. 15		80	
	—	—	" 50 " 60. 10			
	80	80	" 60 " 70. 4			
			" 70 " 80. 1			
			Unrecorded... 3			
			—			
			80			
Femur......... 885	S...... 752	Neck.......... 98	Under 10 yrs.. 152	M.. 745	R..... 349	Cured.......... 601
	S.C... 20	Anatomical neck... 2	From 10 to 20. 164	F... 140	L..... 391	Relieved.......... 44
	C..... 64	Surgical neck........ 2	" 20 " 30. 149	—	U..... 145	Died.......... 111
	C.C... 49	"Extra-capsular".. 16	" 30 " 40. 125	885	—	Unrecorded....... 129
	—	"Intra-capsular"... 49 167	" 40 " 50. 89		885	—
	885	Trochanter.......... 4	" 50 " 60. 76			885
		Upper third.......... 119 290	" 60 " 70. 62			
		Middle third.......... 269	" 70 " 80. 34			
		Condyles.......... 15	" 80 " 90. 17			
		External condyle......... 2	Unrecorded... 17			
		Internal condyle......... 1	—			
		Epiphysis.......... 4	885			
		"Lower third"........ 129 151				
		Unrecorded.......... 175				
		—				
		885				
Patella......... 106	S...... 86		From 10 to 20. 1	M.. 96	R..... 38	Cured.......... 96
	S.C... 8		" 20 " 30. 36	F... 10	L..... 45	Relieved.......... 2
	C..... 7		" 30 " 40. 24	—	U..... 23	Died.......... 8
	C.C... 5		" 40 " 50. 25	106	—	—
	—		" 50 " 60. 16		106	106
	106		" 60 " 70. 1			
			" 70 " 80. 2			
			" 80 " 90. 1			
			—			
			106			

Hospital from January 1, 1850, *to January* 1, 1874.

Amputations.		Deaths after amputation.		Other deaths, causes of.		Principal occupations.	
C.C.	1	Pyæmia	1	Other injuries (C.C., 1; S.C., 1; C., 1)	3	Housewives	174
C.	1			Mania a potu (S., 2)	2	Laborers	117
S.	1			Gangrene (C., 1)	1	School-children	78
	—			Hemorrhage (C., 1)	1	Sewing-women	27
	3				—	Factory-hands	20
Exsection	1			(C.C., 1; C., 3; S., 2; S.C., 1)	7	Seamen	18
						Washerwomen	15
						Drivers	15
						Carpenters	15
						Children	15
C.C.	3			Other injuries (C., 2)	2	Laborers	38
C.	3			Pyæmia (C., 1)	1	School-children	26
	—				—	Housewives	11
	6			(C., 3)	3	Factory-hands	8
Resection	1					Washerwomen	6
						Miners	4
C.C.	29	Pyæmia (C.C., 2)	2	Pyæmia (C.C., 3; S., 1)	4	School-children	94
C.	9	Exhaustion (C.C., 3)	3	Mania a potu (S., 2)	2	Laborers	71
S.	3	Other injuries (C.C., 1)	1	Tetanus (C.C., 1; C., 2)	3	Housewives	49
	—	Erysipelas (C., 1)	1	Gangrene (C., 1)	1	Factory-hands	36
	41		—	Exhaustion (C.C., 1; C., 3; S., 1)	5	Carpenters	9
		(C.C., 6; C., 1)	7	Apoplexy (S., 1)	1	Errand-boys	9
				Bright's disease (S., 1)	1	Mechanics	8
				Injuries (C., 1)	1		
					—		
				(C.C., 5; C., 7; S., 6)	18		
	38		1	Tetanus	2	Laborers	40
				Pyæmia	1	Factory-hands	10
				Exhaustion	1	Carpenters	6
				Phlebitis	1	Mechanics	5
				Injuries	2		
					—		
					7		
				Shock	9	Laborers	26
				Injuries	3	Carpenters	4
				Hemorrhage	2	Railroad-men	4
				Gangrene	1	Housewives	3
				Mania a potu	1	Seamen	3
				Exhaustion	1	Boatmen	2
				Pyæmia	1		
				Peritonitis	1		
				Unrecorded	12		
					—		
					31		
C.C.	10	Pyæmia (C.C., 4)	4	Shock (C.C., 21; C., 7; S., 3)	31	School-children 115	
C.	6	Exhaustion (C.C., 1; S., 1)	2	Exhaustion (C.C., 1; C., 5; S., 6; S.C., 1)	13	Young children 74	189
S.	3	Shock (C., 1)	1	Other injuries (C.C., 2; C., 4; S., 6)	12	Laborers	169
	—	Other injuries (C., 1)	1	Mania a potu (C.C., 1; S., 11)	12	Housewives	74
	19	Unrecorded (C., 1; S., 1)	2	Pyæmia (C.C., 2; C., 5; S., 2)	9	Seamen	37
			—	Compression of brain (C.C., 1; C., 1; S., 1)	3	Miners	23
		(C.C., 6; C., 2; S., 2)	10	Gangrene (C., 1; S., 1)	2	Carpenters	21
				Tetanus (S., 2)	2	Drivers	21
				Chronic meningitis (S.C., 1)	1	Factory-hands	21
				Erysipelas (S., 1)	1	Shoemakers	13
				Peritonitis (S., 1)	1	Railroad-men	13
				Debility (S.C., 1)	1	Painters	12
				Old age (S., 1)	1	Machinists	9
				Epilepsy (S.C., 1)	1	Tailors	9
				Osteo-sarcoma (S., 1)	1	Seamstresses	8
				Unrecorded (C., 4; S., 5; S.C., 1)	10		
					—		
				(C.C., 28; C., 27; S., 41; S.C., 5)	101		
Resection of knee	1	Gangrene following resection (C.C., 1)	1	Mania a potu (C.C., 1; S.C., 1; S., 3)	5	Laborers	30
				Pyæmia (C.C., 1)	1	Housewives	7
				Exhaustion (C.C., 1)	1	Factory-hands	4
					—	Shoemakers	4
				(C.C., 3; S., 3; S.C., 1)	7		

Table of Fractures treated at the Pennsylvania

Bone.	Form.	Position.	Age.	Sex.	Side.	Result.
Tibia........... 315	S...... 255	Upper third........................ 45	Under 10 yrs.. 31	M.. 278	R..... 123	Cured............. 97
	S.C... 11	Middle third...................... 81	From 10 to 20. 61	F... 37	L..... 123	Relieved......... 4
	C..... 35	Lower third...................... 120	" 20 " 30. 63	—	U..... 69	Died 28
	C.C... 14	Unrecorded...................... 69	" 30 " 40. 77	315	—	Unrecorded...... 186
	—	—	" 40 " 50. 41		315	—
	315	315	" 50 " 60. 24			315
			" 60 " 70. 7			
			" 70 " 80. 5			
			" 80 " 90. 1			
			Unrecorded... 5			
			—			
			315			
Fibula.......... 315	S...... 293	Upper third........................ 16	Under 10 yrs.. 9	M.. 273	R..... 113	Cured............. 289
	S.C... 8	Middle third...................... 26	From 10 to 20. 32	F... 42	L..... 105	Relieved......... 15
	C...... 9	Lower third...................... 210	" 20 " 30. 58	—	U..... 97	Died 11
	C.C... 5	Unrecorded...................... 63	" 30 " 40. 107	315	—	—
	—	—	" 40 " 50. 60		315	315
	315	315	" 50 " 60. 37			
			" 60 " 70. 10			
			" 70 " 80. 2			
			—			
			315			
Tibia and Fibula...... 1074	S...... 654	Upper third........................ 70	Under 10 yrs.. 44	M.. 936	R..... 366	Cured............. 765
	S.C... 54	Middle third...................... 282	From 10 to 20. 122	F... 138	L..... 381	Relieved......... 35
	C. 213	Lower third...................... 399	" 20 " 30. 250	—	U..... 327	Died 160
	C.C... 153	Unrecorded...................... 323	" 30 " 40. 277	1074	—	Unrecorded 114
	—	—	" 40 " 50. 199		1074	—
	1074	1074	" 50 " 60. 107			1074
			" 60 " 70. 55			
			" 70 " 80. 14			
			" 80 " 90. 6			
			—			
			1074			
Foot............ 120	S...... 38	Astragalus........................ 7	Under 10 yrs.. 8	M.. 118	R..... 40	Cured............. 89
	S.C... 5	Calcaneum 14	From 10 to 20. 23	F... 2	L..... 43	Relieved......... 8
	C..... 29	Tarsus................................ 25	" 20 " 30. 43	—	U..... 37	Died 23
	C.C... 48	First metatarsal............ 7	" 30 " 40. 28	120	—	—
	—	Third metatarsal............ 1	" 40 " 50. 11		120	120
	120	Fourth metatarsal......... 1	" 50 " 60. 4			
		Fifth metatarsal............ 4	" 60 " 70. 2			
		"Metatarsal".................. 13 26	" 80 " 90. 1			
		Phalanges.......................... 9	—			
		Unrecorded...................... 39	120			
		—				
		120				

Hospital from January 1, 1850, *to January* 1, 1874.

Amputations.		Deaths after amputation.		Deaths, other causes of.		Principal occupations.	
C.C.	3	Exhaustion (C.C., 1, C., 1)	2	Pyæmia (C.C., 1; C., 7; S., 1)	9	Laborers	72
C.	6	Gangrene (C., 1)	1	Injuries (C.C., 1; S., 3)	4	Children	37
	—	Pyæmia (C., 1)	1	Mania a potu (C., 2; S., 2)	4	Drivers	19
	9	Anæsthesia (C.C., 1)	1	Shock (C., 2)	2	Housewives	18
			—	Exhaustion (C.C., 1; C., 1)	2	Sailors	12
		(C.C., 2; C. 3)	5	Erysipelas (C.C., 1)	1	Factory-hands	12
				Old age (S., 1)	1		
					—		
				(C.C., 4; C., 12; S., 7)	23		
C.C.	1	Pyæmia (C.C., 1)	1	Mania a potu (S., 2; S.C., 1)	3	Laborers	102
				Exhaustion (C., 3)	3	Housewives	25
				Shock (C.C., 1; C., 1)	2	Drivers	18
				Tetanus (S., 1)	1	School-children	15
				Peritonitis (C., 1)	1	Factory-hands	11
					—		
				(C.C., 1; C., 5; S., 3; S.C., 1)	10		
C.C.	50	Exhaustion (C.C., 5; S., 1)	6	Shock (C.C., 22; C., 8)	30	Laborers	352
C.	22	Pyæmia (C.C., 5; S., 1)	6	Injuries (C.C., 4; C., 6; S., 1; S.C., 1)	12	Housewives	109
S.	1	Shock (C.C., 2; C., 2)	4	Mania a potu (C.C., 2; C., 2; S., 11; S.C., 4)	19	Children	68
	—	Injuries (C.C., 2)	2	Exhaustion (C.C., 7; C., 8; S., 2)	17	Seamen	28
	73	Secondary hemorrhage (C.C., 1)	1	Pyæmia (C.C., 7; C., 7)	14	Carpenters	26
		Tetanus (C., 1)	1	Gangrene (C.C., 4; C., 1; S., 1)	6	Miners	23
		Gangrene (C., 1)	1	Erysipelas (C.C., 1; C., 1)	2	Drivers	22
		Mania a potu (C.C., 1)	1	Tetanus (C.C., 1; C., 1)	2		
		Convulsions (C.C., 1)	1	Debility (C., 1; S., 1)	2		
		Unrecorded (C.C., 4)	4	Heart disease (S., 2)	2		
				Cardiac embolism (C., 1)	1		
			—	Hemorrhage (C.C., 1; C., 1)	2		
		(C.C., 21; C., 5; S., 1)	27	Variola (C., 1)	1		
				Unrecorded (C.C., 6; C., 15; S., 2)	23		
					—		
				(C.C., 55; C., 53; S., 20; S.C., 5)	133		
C.C.	32	Pyæmia (C.C., 3; C., 1)	4	Shock (C.C., 1)	1	Laborers	33
C.	9	Exhaustion (C.C., 2; C., 1)	3	Injuries (S.C., 1)	1	Children	13
S.C.	1	Mania a potu (C.C., 3)	3	Tetanus (C.C., 1)	1	Seamen	7
S.	2	Shock (C.C., 2)	2	Peritonitis (C., 1)	1	Brakemen	6
	—	Erysipelas (C.C., 1)	1	Debility (C.C., 1)	1	Shoemakers	5
Total,	44	Injuries (C., 1)	1	Mania a potu (C.C., 1)	1	Mechanics	3
			—	Unrecorded (C.C., 1; C., 2)	3	Factory-hands	3
Pirogoff	5	(C.C., 11; C., 3)	14		—	Firemen	3
Lisfranc	2			(C.C., 5; C., 3; S.C., 1)	9		
Chopart	1						

General Summary of the Fractures treated in the Pennsylvania Hospital from January 1, 1830, to January 1, 1874,—Forty-four Years.

Bone.	1830 to 1850. Dr. Norris.	1850 to 1874. Dr. Willard	Total, Forty-four Years.	Per Cent.
Cranium	110	195	305	3.5
Nose	23*	30	53	.6
Face	......	10	10	.011
Superior maxilla	......	24	24	.3
Inferior maxilla	51†	158	209	2.4
Hyoid	......	1	1‡	.001
Vertebræ	25	48	73	.8
Ribs	88	221	309	3.6
Sternum	6	7	13§	.1
Clavicle	188	508	696	8.1
Scapula	28	54	82	.9
Humerus	203	765	968	11.2
Radius	208	777	985	11.4
Ulna	46	172	218	2.5
Radius and ulna	122	477	599‖	6.9
Hand	69	143	212¶	2.5
Pelvis	14	80	94	1.1
Femur	296	885	1181	13.7
Patella	42	106	148	1.7
Tibia	122	315	437	5
Fibula	122	315	437	5
Tibia and fibula	367	1074	1441**	16.7
Foot	52	120	172††	2
Total	2182	6485	8667	

SPECIAL FRACTURES.

Fractures of the Vertebræ.

When we consider that one of the important offices of the spinal column is to furnish a canal for the spinal marrow and foramina for the safe conduct of the moto-sensory nerves to the outstanding organs, it can be no matter for surprise that its injuries should prove so grave. Buried deeply though the column is, in the midst of very numerous and massive muscles, its components bound together by several articulations and by powerful ligaments, yet it is frequently the subject of fracture.

This injury is produced in three different ways: first, by force directly applied to the spine, as when a loaded wagon passes over the prostrate body, or when it is crushed beneath a heavy piece of timber; second, by indirect force, as where a person falls from a considerable height, alighting upon the head, the buttocks, or even the feet; and, third, by extreme flexion of the column, as often occurs to quarrymen, upon whom heavy masses of earth cave in, bearing the body down under the superincumbent weight.

Women suffer less frequently from this lesion than men, a fact due to the difference in the occupations of the two sexes. Gunshot fractures of the spine are not uncommon accidents, and are often comminuted in their character.

The seat of the fracture varies in different cases. It may be in the body, in the intervertebral cartilages, in the arches, or in the spinous, transverse, or articular processes.

* Face included.
† Upper jaw included.
‡ Total head, 597.
§ Total trunk, 395.
‖ Forearm, 1802.
¶ Total upper extremity, 3760.
** Total leg, 2315.
†† Total lower extremity, 3910.

Diagnosis.—Except in fractures of the spinous processes, where the damaged part is entirely accessible to the touch, we cannot affirm the existence of such an injury with any degree of certainty. The presence of certain symptoms, following a sufficient cause, furnishes ground for supposing the existence of a fracture, and yet these may all be present without any injury of the kind. The prominent symptom is paralysis; this is due to pressure upon the spinal cord or its nerves, and may follow any violence which is sufficiently powerful to rupture a blood-vessel or to produce inflammatory transudations. If, however, the paralysis follows on the instant of injury, is persistent, and especially if deformity is present, the presumption is that a fracture exists, and that the cord is or has been subjected to pressure from a displaced portion of bone.

I say *has been*, inasmuch as in very many cases there is no permanent pressure on the cord, the fragment which inflicted the lesion having been only momentarily in contact with it, and rebounding as soon as the force of the blow was expended.

If the paralysis is developed only after several hours, and no deformity or preternatural mobility is discoverable, it may be that the concussion has produced a lesion of some of the vessels within the canal, and the gradual leakage of blood at last makes sufficient compression on the cord to suspend its functions. There is reason, however, to believe that such effusions of blood are not common. When the paralysis is delayed for days, it will probably be due to an inflammatory effusion of serum or of lymph, or to inflammatory softening of the cord.

The medulla spinalis, being attached at either extremity of the canal, may suffer a lesion of its substance by being overstretched in extreme flexion of the spinal column, without the latter being broken, and paralysis may follow from this cause.

Fractures of the Spinous Process.—Fractures of the spinous processes are the least dangerous of these injuries, and can be diagnosed without difficulty, in consequence of their superficial situation. Those over the lower half of the dorsal part of the column, being imbricated, are less likely to yield than those in the cervical, upper dorsal, or lumbar regions, which stand more horizontally. The force which strikes these processes in a downward or in a lateral direction will be most favorable for the production of a fracture. Bound as they are to each other by supra- and interspinous ligaments, and with muscles placed along either side, not much displacement need be expected, unless the force has been of a crushing nature. The direction of the fracture is usually transverse. (Fig. 624.)

Symptoms.—Pain is experienced in the part, the detached apophysis can be taken between the thumb and the finger and moved, and the crepitus may be felt during such manipulations. When the body is bent forward, the tendency to separate the processes from each other, together with the tension of the integuments, increases the deformity and aggravates the suffering. When the trunk is extended and pressure is applied over the seat of injury, there will appear a hollow space, or deficiency, in the line of the spine. In addition to the foregoing symptoms there will often be discoloration of the superincumbent soft parts.

Prognosis.—Should the case progress a few days without any symptom of injury to the cord, such as paralysis, a favorable termination may be expected. If the reduction is accurate, union will take place; although cases are recorded where a false joint was formed. In a case which I had under care, occurring in a young man, the detached portion remained for several months movable, finally became necrosed, and was discharged through a sinus.

Treatment.—If the process is displaced, it should be adjusted, provided it does not assume a proper position when the body is in position. The muscles are competent in some cases to effect a spontaneous reduction after recovering

from their temporary paralysis, the consequence of the injury. The patient should be placed in the recumbent position, on the back, upon a firm mattress, and with a low pillow under the head. A lotion of lead-water and laudanum should be applied over the seat of injury. If the pain is persistent, a few leeches may be applied with advantage over the seat of fracture.

Fig. 624.

Fracture of the spinous process, and a double fracture of the lamina on one side.

Fractures of the Vertebral Arches.—The arches consist of the pedicles and laminæ. When we consider the relation of the spinous process to the laminæ, it is not difficult to understand how a force received at the summit of the former can be transmitted to the latter, so as to sever this part of the arch on either side. The danger to the cord in such a fracture is imminent. (Fig. 624.) Even should there be no displacement, there will remain the risk of subsequent inflammation.

Unless, as in the case recorded by Olliver, the lamina can be felt to move by acting on the spinous process, it will be impossible to distinguish such an accident from one involving the bodies of the vertebræ, and therefore we may consider these injuries with those of the latter.

Fractures of the Bodies of the Vertebræ.—Fractures of the bodies of the vertebræ may be produced by falls upon the head, sacrum, or feet; by forced flexion of the body under crushing weights, as the falling in of sand-banks; or by being caught under scaffoldings.

I once examined the spine of a patient who jumped from a third-story window, alighting directly upon the feet. The os calcis was ground to pieces, the tibia extensively broken, and a fracture of the eleventh dorsal and third and fourth lumbar produced.

That violent flexion of the spine enters largely into the modus of such injuries there can be little doubt. Malgaigne remarks that there are three marked flexible points in the spinal column: the first, between the third and seventh cervical vertebræ; the second, between the eleventh dorsal and the second lumbar; and the third, between the fourth lumbar and the sacrum. These are points where flexibility and inflexibility meet, and near these positions fractures most frequently occur. The cases recorded by Olliver (twelve in number), and those of Dupuytren (thirteen in number), with those mentioned by Packard and others, seem to corroborate the statement of this author; but an analysis of the forty-eight cases contained in the general table of fractures fails to sustain this statement, and, except in the cervical region, the same is true in the collection of cases tabulated by Dr. Ashhurst.* The direction of these fractures may be transverse, oblique, or vertical, and sometimes the lines run in different directions, as when the bone is comminuted or crushed. There may also be an associated fracture of the arches. When the direction is oblique, Malgaigne states (and his word is borne out by the observation of others) that the direction is always from above downward, and from behind forward, allowing overlapping by the upper fragment sliding down, as on an inclined plane, unless checked by the ligaments. The cord may be contused and pressed upon, or it may be entirely severed. (Fig. 625.)

Symptoms.—These will be determined by the displacement and by the particular section of the column involved. Pain, aggravated on movement, and also by pressure; discoloration and tenderness; want of correspondence in the line of the spinous processes; occasionally deformity of the spine;

* Injuries of the Spine, Ashhurst.

paralysis; disorder of the sexual organs, as manifested by priapism; an increased temperature, together with phosphatic urine, are among the symptoms commonly belonging to this accident.

Prognosis.—In all cases of fracture of the spine the prognosis is unfavorable. The circumstances to be considered in forming an opinion are the region involved, the dangers increasing as we ascend the column, in consequence of the important organs implicated; the amount of injury sustained by the cord from contusion or subsequent inflammation, and from sloughing of the soft parts.

Fig. 625.

Comminuted fracture of the vertebræ, in which the spinal cord was completely severed.

Fractures of the Dorso-Lumbar and Lumbar Region.—Fractures occurring within the limits of this region,—that is, between the tenth dorsal vertebra and the sacrum,—if attended with displacement, will be followed by paralysis of those parts which receive their endowments from the lumbar and sacral plexus. The lower extremities will become powerless and devoid of sensibility, as will also the muscles of the rectum and the anus, giving rise to incontinence of the fæces. The urine, at first retained, soon begins to dribble. There will be also a change of temperature: the lower extremities, though quite pale, may exceed 100°. One limb may be of a different temperature from the other, and the same limb will vary in its heat at different times. The main arterial trunks may be full, although the capillaries are comparatively empty. This is due to the paralysis of the vaso-motor nerves of the vessels. Yet it is within the limits of this region that we have ground to hope for recovery.

The spinal marrow in the lower part of the dorsal and through the lumbar and sacral vertebræ becomes a leash of nerves, the cords of which are surrounded by a firm fibrous investment, and, sliding freely on one another, they glide out of the way of displaced fragments of broken bone, and thus escape serious damage. This fact was long since noticed by Dr. Shaw.

Cooper states that fractures in the lumbar region, with displacement, prove fatal in from four to six weeks; in the dorsal region, in two or three weeks; in the three lower cervical vertebræ, from the third to the seventh day; and above the third vertebra, almost immediately.

Dupuytren* gives two cases at the Hôtel-Dieu,—one a fracture of the tenth vertebra in a male, and the other at the lower part of the dorsal region in a female,—in which the patients, after some months' confinement, both recovered, although partial paralysis was present.

In the London Hospital Reports,† five cases of fracture in the lower dorsal and lumbar regions, with paralysis, are reported, all the patients recovering in from four to six months.

Lente and Thompson‡ each give an instance of recovery after fracture of the lower dorsal vertebræ, with paraplegia, after six months' convalescence.

* Dupuytren, pp. 356, 357, translation by F. Le Gros Clark.
† London Hospital Reports, 1840, p. 326.
‡ American Journal of the Medical Sciences, October, 1857, p. 361.

Malgaigne* treated a case at the Hôpital des Cliniques, in 1843, in which a lumbar vertebra was broken, accompanied with paraplegia; the patient recovered, and the paralysis passed gradually away.

Dr. Shaw† furnishes four cases of fracture in the mid-lumbar region, without paralysis, all of whom recovered.

Quite a number of cases of prolonged life after very severe fractures, attended with displacements in this region, might be collected.

Mr. Key records the case‡ of a boy with a fracture of the first lumbar vertebra, who survived an entire year, notwithstanding the fact that the cord was divided across.

Mr. Birch§ had a case which lived over two years, and finally died from gangrene of the nates.

The same author|| relates the case of Mr. Harrold, in which the patient, a man twenty-eight years of age, fractured his first and second lumbar vertebræ. A fragment had transfixed the theca vertebralis, followed by paralysis of the bowels and bladder. The patient survived the injury nearly one year, and finally died of a slough over the nates.

Mr. Hutchinson reports a case¶ of a fractured lumbar vertebra in which the cauda equina was raised one-third of an inch by a displaced fragment, without other injury.

Mr. Le Gros Clark gives a very remarkable case** of a fracture of the fourth lumbar vertebra at its pedicles on each side, with comminution of all its processes, so that its body assumed a position in front of the fifth vertebra, the upper and lower surfaces of these vertebræ being on the same plane; and although there was complete paraplegia succeeding the accident, in five weeks sensation was restored completely, and motion to some extent. Death occurred in the seventh week.

In a case of fracture of the last dorsal vertebra, which I saw two years ago, and in which the paralysis of the lower extremities was complete, the patient recovered sufficiently to make a sea-voyage, and I believe is still living. A young man was caught at the Kensington Depot, Philadelphia, between the platform and a car, and, notwithstanding the spinal cord was completely severed in the mid-dorsal region by a permanently displaced vertebra, yet he survived the accident six months, perishing at last from sloughing of the nates. (Fig. 625.)

Fractures of the Dorsal Vertebræ.—As we ascend the vertebral column, the spinal canal becomes smaller, particularly in the middle third of the dorsal region. In the ordinary movements of the body this division of the column is least disturbed, and hence no necessity exists for a canal more capacious than is necessary for the lodgment of the cord, but when this part of the spine becomes the subject of fracture, for the same reason,—that is, the smallness of the canal,—the danger to the medulla spinalis is imminent. Viewing the subject from both an anatomical and a physiological standpoint, we shall confine ourselves to those fractures which occur between the eleventh and the second dorsal vertebra. Every step that we ascend in this region an additional section of the body is involved. We not only have paraplegia,—loss of power in the rectum and bladder,—but paralysis of the abdominal muscles, as well as of the muscular coat of the intestines. This state of the walls of the abdomen renders it needful to enforce a caution against turning the patient on the breast for examination, as, through the want of resistance on the part of the abdominal muscles, the viscera may be thrust up against the diaphragm, and by preventing its descent arrest the respiration.

* Malgaigne's Treatise on Fractures, p. 342, by Packard. † London Medical Gazette, vol. xvii.
‡ Cooper on Dislocations and Fractures, p. 467, American edition.
§ Ibid., p. 388. || Ibid., p. 390.
¶ London Hospital Reports, vol. iii. p. 360.
** Lecture on the Principles of Surgical Diagnosis, by Mr. F. Le Gros Clark, British Medical Journal, Oct. 3, 1863.

When this portion of the column is the seat of fracture and the cord is compressed, there is generally a difficulty of breathing or a sense of suffocation. This is due to the imperfect manner in which the act of expiration is accomplished. It is common to hear it stated that expiration is a passive act, depending on the elasticity of the thoracic walls; but, if so, why should this difficulty in breathing be experienced, after these fractures? Expiration is both passive and active, and the difficulty witnessed in these cases must be referred to the loss of power, by paralysis, of the abdominal muscles,—the serratus posticus inferior, quadratus lumborum, sacro-lumbalis, and longissimus dorsi muscles, which are concerned in the expiratory act; the distention of the intestines with gas, giving rise to tympany, tends also to increase the difficulty of breathing, by causing pressure against the diaphragm. Another distressing attendant of these cases is the tendency to form sloughs over those portions which sustain the pressure of the body, as the nates, the parts over the sacrum, and even the hard tissues of the heel.

The nearer the fracture approaches the upper limits of this region, namely, to the second dorsal vertebra, the greater will be the embarrassment to respiration, as a larger number of the intercostal muscles are involved in the paralysis. As the respiratory process is thus implicated, the lungs become congested, a sense of suffocation ensues, the air-passages fill with mucus which the sufferer is unable to dislodge or expectorate, and he may die in a state of progressive asphyxia.

Fractures in the Cervico-Dorsal and Cervical Regions.—The brachial plexus of nerves is formed from the three or four lower cervical and the first dorsal nerves; the long thoracic, or external respiratory, from the fifth and sixth; and the phrenic, from the third and fourth cervical nerves. This region extends from the second dorsal to the fourth cervical vertebra. There will be, in addition to the paralysis present in the fractures of the previous regions, motosensory paralysis of the upper extremities, to a greater or less degree, according to the particular vertebra involved. If it be the first or the second dorsal, it involves but one cord of the brachial plexus, and therefore does not entail entire loss of power; but if through the pieces of the lower cervical, the other cords of this plexus will suffer, and then the paralysis becomes complete. The difficulty of respiration is much increased when the great serratus muscle is rendered helpless, as its nerve-endowments are derived from the fifth and sixth cervical nerves, which form the long thoracic or external respiratory. The same increase of temperature, and the same round and full state of the radials and other large arteries of the parts, will be present, as in paralysis of the lower extremities. The surface of the skin will exhibit a blanched and dry appearance. The pupils refuse to dilate, a symptom which Mr. Hutchinson claims is present only when the injury is in the cervical or upper dorsal vertebræ. The same author states that priapism is only seen when the damage is in the upper or middle dorsal region, and that he has never witnessed it after injuries affecting other parts of the cord, or the head. I have, however, seen it present in injuries of the latter. These erections of the penis are not due to action of the muscles, as the latter partake of the general paresis, but are the result of inefficiency of the vasomotor nerves allowing the blood to flow into the spongy structure of the corpora cavernosa and corpus spongiosum, through the want of resistance in the muscular walls of the vessels. The heart is not free from disturbance in these cervical injuries. Its action is slow and full, though free from intermission.

It is difficult to conceive of a more pitiable condition than that of a fellow-being without the power of motion or sensation, practically dead to the neck, and suffocating from imperfect aeration. Yet, even under such circumstances, patients sometimes live four or five days, breathing only by the diaphragm; and some have even recovered. Mr. Hutchinson furnishes two instances,* the one a female and the other a male, of fracture in the lower

* London Hospital Reports, 1866, vol. iii. pp. 347, 348.

cervical region, accompanied by partial paralysis, in both of which the patient recovered. Mr. Hilton has placed on record a remarkable case* of a boy in whom there was fracture of a cervical vertebra, followed by paralysis of the upper and lower extremities and paralysis of the bladder and rectum, yet who lived fourteen years, coming to his death at last by an accident. The case of Mr. Page, recorded by Mr. Shaw,†—in which a Scotch gentleman fractured the fourth cervical vertebra, every part being paralyzed except his head, and yet lived for nearly fifteen months,—is still more wonderful.

A lad, in diving, struck his head violently upon the bottom of a shallow stream, and produced a fracture about the third cervical vertebra. Though paralyzed from the neck down, he was living five months after the accident.

Should the fracture occur above the fourth cervical vertebra and the cord sustain damage, the case will prove fatal in a brief period of time. The phrenic nerve, which is the motor nerve of the diaphragm, has its origin below this point, and suspension in the action of so important a muscle as this must be quickly followed by death. There are, however, a few exceptions to this sudden result. Mr. Curling furnishes an example of a fracture of the three upper cervical vertebræ, in which the patient survived twenty-eight hours. The explanation given was doubtless correct, namely, that only a partial injury was inflicted on the cord, and that the change discovered in the medulla spinalis on dissection took place subsequent to the injury.

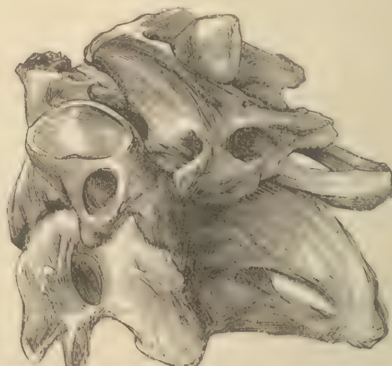
Hamilton states‡ that of 10 fractures of the five lower cervical vertebræ which he has collected, 1 died within twenty-four hours, 1 in eleven days, 1 in fifteen weeks and six days, 1 in four months, and 1—which I have recorded as the case of Mr. Hilton—lived fourteen years.

The two upper cervical vertebræ, being placed at a point where force and counterforce meet, frequently give way, especially when the momentum is transmitted through the cranium. The fracture may extend through either the anterior or the posterior arch of the atlas, or it may detach the odontoid process of the axis from its attachment to the body. (Fig. 626.) The spinal

Fig. 626.

Fracture of the odontoid process.—Hamilton.

Fig. 627.



Fracture of the odontoid process. The patient lived ninety-eight hours.

canal of these pieces is quite large, and, should no displacement occur, the cord may escape injury. The odontoid process when broken tends to escape from the transverse ligament, or the ligament itself may be torn, completely liberating the process, which may be forced into the cord. Fig. 627 is an illustration of a case, seen in consultation with Dr. Willard, of a comminuted fracture of the odontoid process without rupture of the transverse ligament, and accompanied by a unilateral luxation.

* London Lancet, October 27, 1860.

† Holmes's System of Surgery, vol. ii. p. 393.

‡ Fractures and Dislocations, p. 155.

In instances of fracture of the odontoid process with displacement, the head is rigidly maintained in a fixed position, in cases of unilateral displacement it is turned to the opposite side, and in both conditions there is an unusual prominence of the larynx. Motion and sensation may at first be unimpaired, but in the course of a few hours paralysis sets in, which may affect one side alone. In addition to these symptoms, the diagnosis of the injury may be established by the presence of an undue prominence of the posterior wall of the pharynx, formed by the body of the displaced vertebra. It is extraordinary what extensive damage may be inflicted and the cord escape serious lesion. Dr. Stephen Smith, in a paper on "Fractures of the Odontoid Process,"* has collected 22 cases. Six of these were spontaneous fractures, with 1 recovery; the one recovering discharged a portion of the bone through the throat; 4 were produced by gunshot injuries, all of whom died; 7 by external violence, all fatal; of 5 cases (two obtained from dead subjects) in which a portion of the bone had been discharged, 4 recovered and 1 died: making a total of 17 deaths and 5 recoveries. Robert Debenham, Esq.,† gives the case of a shoemaker who had a fracture of the odontoid process and recovered, the fracture having been verified by dissection two years after the injury. Dr. Sinkler has furnished me the notes of a case of what was considered a fracture of the odontoid. There was paralysis of both arms and of one leg, deformity below the occiput, and the chin was depressed on the sternum. This patient gradually recovered. Cooper‡ mentions a case, afterwards verified by dissection, of a boy who, by a fall, broke the atlas across, so as to remove the support of the tooth-like process of the axis. The lad was obliged to walk with the utmost circumspection; if desirous of examining any object below himself, he would place his hand under the chin and lower his head so that he could direct his eyes towards the object; if he wished to look upwards, one hand was placed behind the occiput and the other under the chin, and the head gradually raised. These precautions were instinctive, and were adopted in order to prevent the dentiform process from damaging the cord. He was able to go about and play with other children, and lived for a year after the accident. These symptoms are present in most cases of fracture of the odontoid process. Dr. Willard Parker, of New York, met with a case of fracture of the odontoid process, in which the patient lived five months, his death being caused by the process becoming displaced to such a degree as to injure the cord. A still more remarkable case is mentioned by Mr. Shaw, from a description by Mr. B. Phillips,§ under whose care the patient was at the time of the accident. The man fell from a hay-rick, striking on his head, but was in a little time able to rise and to visit his physician. In two days he was about, but had an enlargement at the back of the pharynx, with some difficulty in deglutition. One year after, he died from dropsy, and on examination not only was the atlas found broken, along with the odontoid process of the axis, but its anterior portion had been carried forward and placed in front of the axis, and the occipital bone had settled down and rested on the posterior ring of the atlas, which last had become united to the body of the axis.

Cases of spontaneous fracture of the odontoid process from disease have been reported by Hyrtl, Else, and Flint, death in each instance taking place instantaneously.

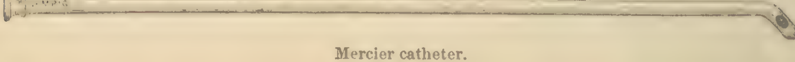
Treatment.—The moment a patient is extricated from a caved-in sand-bank, or from the midst of the rubbish of fallen timbers, or when lifted from the street or ground, and there is evidence of a broken spine, he should be straightened out and laid on his back, and so transported on a board, or on a settee, to his home, or to a hospital. This position is most favorable to the reposition of the bones, and best adapted to remove pressure

* American Journal of the Medical Sciences, Oct. 1871, p. 388.
† London Hospital Reports, 1867, vol. iv. p. 210.
‡ Fractures and Dislocations, p. 385.
§ Medico-Chirurgical Transactions, vol. xx. p. 78.

from the cord or from the spinal nerves. If the fracture is in the cervical region, the head should be maintained in a fixed state by applying pillows or a portion of the clothing to each side. Next in importance is the bed upon which the patient is to be placed. The water-bed is superior to all others when the case is likely to be protracted. It must be borne in mind that one of the consequences of this class of injuries is bed-sores, and many die of these alone. They result from the continuous pressure upon the salient points of the body, which possess but a very feeble capillary circulation, and are therefore disposed to slough. A man with a fracture, say of the dorsal vertebræ, without the power of motion in the parts below, is absolutely fixed to the spot on which he is laid, and, being without sensation, never feels the weariness or unrest of immobility, so that this pressure knows no abatement. Water-beds can be obtained at any large establishment for the sale of rubber goods, and cost about twenty dollars. A small size is made, or a section, which is sufficiently large to extend from the shoulders to a little below the hips, and answers very well. Many persons of course cannot afford this expense, and in some localities there would be difficulty in obtaining such a convenience. In this event, an ordinary mattress, protected with oil- or gum-cloth, can be substituted, and, with the addition of stuffed or air cushions, having openings to receive the tender points of the body, may obviate the evils resulting from pressure. The patient, once placed on his bed, should have a pillow slipped beneath the loins, in order to keep the spine from sinking down. It has been advised to employ extension and counter-extension, with a view to correct any displacements which may exist; but the value of this course is very questionable. The benefits claimed for such a process in the few cases in which it has been used are by no means conclusive. It must be remembered that of twenty autopsies made by Hutchinson* in cases of broken spine, in none was there any evidence of permanent compression of the cord. The injury to the medulla spinalis is in most instances, as I have previously observed, a momentary work, and done at the instant of the accident. The state of the skin, moreover, is such that no extension would be tolerated long without producing sores.

Attention should next be directed to the condition of the hollow viscera. The bladder is at first unable to expel its contents, and the catheter must be used to remove the urine. In executing this task the utmost care should be exercised. The urethra being without sensibility, there is no monitor to communicate any injury which it may sustain. The only instrument which should be generally used in these cases is the gum catheter of Mercier (Fig. 628). It will produce the least possible irritation. The urine should be

Fig. 628.



Mercier catheter.

drawn three or four times in the twenty-four hours. After a time, incontinence sets in, and then the patient must be furnished with a urinal to receive the secretion as it flows away. Even after this incontinence begins, the catheter should be used once every twenty-four or forty-eight hours, in order to remove any water which may lie below the level of the urethra, which by its decomposition would aid in producing vesical inflammation. This practice is contrary to some very good authorities, but I am convinced of its necessity. The bladder, in these cases, is prone to become inflamed, and the urine cloudy and ropy, with a strong ammoniacal odor and an alkaline reaction. The phosphates, particularly of lime, are present in great abundance, the result of a faulty action of the kidneys, from the interruption of the proper nerve-influence, as well as of reactions which

* London Hospital Reports, 1866, vol. iii. p. 359.

take place in the bladder. These chemical alterations in the composition of the urine result in sedimentary deposits, which are exceedingly prejudicial, and should therefore not be allowed to remain in the bas-fond of the bladder. It will sometimes prove beneficial to wash out the organ once a week with lukewarm water containing three or four drops of nitric acid to the pint of fluid. For this purpose the double catheter may be used (Fig. 629), the nozzle of a syringe or a gum-bag being fitted to one of its orifices.

FIG. 629.

Double catheter.

The bowels, like the bladder, at first allow their contents to accumulate, but very soon the evacuations pass without the patient being conscious of the act. When they do not act, it is proper to administer a cathartic, the reflex sensibility being sufficient to secure its operation. As the patient is entirely unable to discover either the dribbling of urine, the escape of fæces, or any injury of the soft parts, the utmost care should be exercised by nurses or other attendants to see that the person is kept perfectly dry and clean. While it is desirable to keep the patient entirely quiet on the back, to prevent the broken fragments of the vertebra from moving on each other, yet the great danger of bed-sores renders an inspection of the parts over the sacrum and nates absolutely necessary, and therefore the body should be daily turned over on the side, avoiding any twist by carefully moving the shoulders and the hips at the same time (if the fracture is in the lumbar or the dorsal region), when the exposed parts must be well washed with alcohol, or soap liniment, rubbed briskly, and afterwards smeared over with a little zinc ointment. The draw-sheet should be kept smooth and dry, and, to receive the discharges from the bowels, a pad of oakum containing some carbolated plaster of Paris may be pushed a little behind the anus. Should bed-sores form, in defiance of all precautions, the indications will be to favor the separation of the sloughs and to stimulate healthy granulations. To effect the first object there is nothing better than large, warm flaxseed-meal poultices over which compound resin ointment has been spread; these are to be renewed morning and evening, cutting away any dead shreds of cellular tissue that may loosen, and after the parts are entirely freed from the sloughs a dressing of the compound resin ointment alone may be applied. If any offensive odor is present, the carbolic acid lotion, or the permanganate of potash, or a solution of the nitrate of lead, will answer every purpose for its removal. I have succeeded in healing up such sores, when obstinate, by covering them in with strips of adhesive plaster. During all this time we must never forget the necessity for taking off the weight of the body from the diseased parts by interposing ring cushions. Nor must the extremities be overlooked. The calf of the leg and the heel are also liable to become sore. Happily, in these situations, the pressure can be distributed by cotton or soft compresses. Should the patient be fortunate enough to escape the usual dangers and begin to recover his lost power, electro-galvanism may be employed with advantage. Throughout the entire progress of the case a nutritious but unirritating diet should be allowed.

The use of the trephine to raise depressed portions of fractured vertebræ would very naturally occur to a thoughtful surgeon. The suggestion was made as far back as Paulus Ægineta. It was first practiced by Sir Henry

Cline, in 1814, on a patient who had a fracture of the eleventh and twelfth dorsal vertebræ. The spinous processes of both vertebræ and the arch of the eleventh were removed. No benefit resulted, and the patient died on the third day after. The operation has been repeated many times, without success. The table of Dr. Ashhurst* is the best commentary on the operation. Of 38 cases collected, 29 died, 3 were relieved, 2 were not relieved, and in the remaining 4 the result was unknown.

In reference to the mortality following fractures of the spine, as they have occurred in the Pennsylvania Hospital, and which I suppose does not materially differ from that of other similar institutions, some idea may be obtained by consulting the tables on fractures, from which it will be found that of the 73 cases treated in that institution, 47 died in the hospital, 17 were removed by friends, and most of these in all probability subsequently died, 1 was reported cured, and 2 remain unrecorded.

Fractures of the Bones of the Face.

The bones of the face, from their exposed position, are very liable to fracture. The relation which they sustain to the cranium, and of course to the brain, makes these injuries sometimes of very serious import.

Fractures of the Ossa Nasi.—The force producing such fractures is usually direct, and may be delivered either immediately in front or on one side. The direction of the fracture may be transverse, oblique, or longitudinal. Transverse fractures are most common. In most of the cases which have come under my observation, the line of fracture was about half an inch above the lower margin of the bone. The upper or frontal portions of these bones are very thick and strong, and will resist a great degree of force without fracture. If the violence is great, a comminuted fracture may be produced. As the parts swell very quickly, these injuries are often overlooked, and hence, in a majority of the specimens which are seen in cabinets, more or less deformity exists: in my own collection that deformity is generally a lateral one, the nose being turned to one side. Commonly, but one bone is broken. When the lesion is longitudinal, the nose will be depressed.

Symptoms.—The symptoms of this fracture are epistaxis, swelling, deformity, mobility, and crepitus. The strictest examination should be insisted upon where there is reason to suspect a lesion of these bones. If there is flattening or a lateral deviation of the nose, even though crepitus is not discovered, the existence of a fracture may be assumed, and, if the displacement is not corrected, the surgeon will incur great blame, especially if the patient is a female.

Treatment.—The reposition of the fracture is most conveniently effected by introducing an ordinary steel director through the anterior nares and conducting it along the side of the septum to the roof of the nasal fossa, when it can be used as a lever to raise the depressed fragments into place. The fingers on the outside, by making counter-pressure, will also aid in modeling the parts into form. Sometimes it will require a considerable amount of force to correct the displacement, in which case the surgeon must have no hesitation as to employing it. Once in place, unless the fracture is a comminuted one, there will be little tendency in the fragments to resume their unnatural position. If there is reason to believe that the reduction has not been complete, in consequence of the inflammatory swelling masking the parts, a few leeches, if they can be obtained, may be applied, and, after a sufficient amount of blood has been taken, the nose should be covered with a lotion of lead-water and laudanum. In twenty-four hours the swelling will have materially abated, and the medical attendant may then ascertain with more certainty the condition of the bones, and, if necessary, renew his efforts at adjustment. These early attempts at reduction are all-important, as the process of repair

* Injuries of the Spine, Ashhurst.

goes on with great rapidity in these bones, the pieces often becoming united in ten or twelve days. Should the patient be young or restless, ether may be administered before attempting the coaptation, always remembering to keep the throat cleared of blood. The fragments being restored to their place, little is to be done but to direct quietness on the part of the patient. I have no objection to the adhesive strips which are generally directed to be placed across the nose: they serve to remind spectators of the accident, and to prevent unwarrantable liberties being taken with the organ; though their influence in keeping the bone from sinking amounts to nothing. If the integuments or the muscles were closely adherent to the bone, such supports would be desirable; but no such adhesions exist,—the muscles slide freely over the bones, and we can exercise through them no lifting power upon the latter.

Complications.—The nasal bones rest on the perpendicular plate of the ethmoid, which forms a portion of the nasal septum. This plate may be broken and deflected from its median position. This will tend to obstruct the nasal fossæ and will allow the nose to sink and become flattened. The septum is not unfrequently found curved to one side as a natural condition, a fact which should be remembered when making examinations of the injuries of this organ. When broken, the nasal bones should be first elevated, and then the perpendicular plate should be pressed into proper line. If the distortion is great, it may carry with it the cartilaginous septum to such a degree as to turn the end of the nose to one side.

The perpendicular plate of the ethmoid is continued up into the cranium as the crista galli, on the sides of which are attached the cribriform plates of the bone, which support the olfactory bulbs. These plates may participate in the injury, or the olfactory lobes may suffer concussion, causing a suspension or even destruction of the sense of smell. In some instances the damage done to the base of the brain results in death.

The contiguity of the nasal bones to the lachrymal duct explains the disorders of the tear-sac, such as abscess, fistula, etc., which sometimes follow extensive fracture of this part of the face, and may demand operations for their relief.

Hemorrhage.—This, though at first profuse, is seldom a troublesome complication. It generally ceases after the broken pieces are adjusted. When it is persistent, the head and shoulders should be elevated, and cold applications placed over the nose; alum-water may also be injected into the nasal cavities. If the bleeding, in spite of these precautions, continues uncontrolled, it will be necessary to employ the tampon.

Emphysema of the eyelids and face constitutes another complication, not, however, of a very serious nature. Its presence indicates a rupture of the mucous membrane of the nose and of the periosteum, allowing the air to pass through the aperture in the bone into the cellular tissue of the face. This air will gradually disappear as the healing of the fracture advances, but its removal may be facilitated by applying a compress over the closed eyelids and upper part of the face, taking care not to place it over the fracture, for fear of disarranging the fragments.

Comminution.—When the bones have been broken into several pieces, the greatest difficulty will be experienced in preserving a proper adjustment. It is in such cases that it may become necessary to attempt support from within. For this purpose various contrivances have been in use, dating back to a period as early as Hippocrates, such as plugging the nostrils with charpie, the use of tubes of various kinds made of quills, lead, silver, wax, and even gold, as recommended by A. Paré, or rubber, by Boyer. The inconvenience and distress which follow the introduction of solid plugs into the nares, compelling the patient to breathe through the mouth, a sorry substitute for the nasal passages, render it necessary that these internal supports, when used, should, if possible, be hollow. One of the best plans is to cut a gum catheter the proper length, and, inserting it into the nose, pad

around it with a strip of old linen well greased and pressed into position with a director. Should the reduction be unsatisfactory, a piece of compressed sponge, shaped to conform to the nasal fossa, and coated with a thin layer of melted wax, may be inserted. The moisture of the parts penetrating the tent will cause the latter to swell and to find its way into the irregularities of the cavity, thus carrying the fragments into position. If this be retained for twenty-four hours before being withdrawn, the tendency to displacement will have materially diminished, and if needful a second tent can be inserted. Hippocrates, Avicenna, Albucasis, and others, after reduction moulded to the external surface of the organ shields made of flour and white of eggs, and sometimes of glue. All such devices are of doubtful value, and only when a tendency to external displacement exists are outside compresses advisable.

In *compound fractures* it is proper to insert one or more points of the silver suture, and if comminution is added to the external wound, the pieces, unless they are entirely detached from the surrounding parts, should not be removed.

Necrosis may follow especially compound comminuted fracture of the nasal bones, and when a fragment is well separated and loose it should be carefully picked away. Displacements of the cartilaginous septum, which are sometimes conjoined with fracture, are generally followed by unavoidable deformity, such as sinking of the nose at the point of junction between the cartilaginous and the bony portions, or lateral inclination of its extremity. Padding the nostrils after the manner already described will measurably prevent this, or, if this is inadequate and the depression is marked, it may even be proper, after the manner of Hamilton, in order to release the cartilage from its unnatural position, to make incisions with a tenotome through its substance, and then, inserting a thread deeply into its structure, to lift into place the sunken portion, and there retain it by tying the ligature over a rubber arch previously thrown over the nose, with its extremities resting on the sides of the face.

Polypi and catarrhal disease of the Schneiderian membrane are said to follow fractures of the nose. The latter I have seen, but never the former.

Amaurosis has been known to succeed this injury. Dr. John W. Martin* reports such a case. The sight was after some time restored.

Fractures of the Superior Maxilla.—The force which produces a fracture of the upper jaw must, as a rule, be direct, and also of great violence. A kick from a horse, a blow from a lever suddenly released from restraint, the impact of a pistol-ball, are among the most common causes of this injury. The fracture is often comminuted, and is sometimes attended with concussion of the brain, or with fracture of other bones of the face or at the base of the skull. Associated as the upper jaw is with no less than nineteen bones, such results create no surprise, as the blows which it may receive are transmitted by these conducting lines of articulations far beyond its own limits. This extensive connection of the upper maxilla will explain the modus of the singular accident narrated by Packard,† where a man's head was caught between a hoisting-machine and the floor, causing the entire separation of the face from the cranium; also the case of a boy, recorded by Wiseman‡ and referred to by Hamilton, in whom the entire face was driven in, so that the finger could not be passed behind the palate. In this case the restoration could be effected only by introducing a blunt hook between the posterior wall of the pharynx and the palate bones, drawing the parts forward and holding them in position until the disposition to recede was overcome. Dr. Fyffe§ published the case of a man brought into the Westminster Hospital who had been thrown from a cab, the vehicle turning over upon him, which, in addition to producing a fracture of the lower and

* Medical Press and Circular, September 23, 1874, Hamilton.
† Malgaigne on Fractures, Packard's translation, p. 303.
‡ Treatise on Surgery, 1734.
§ Lancet, July 18, 1860.

upper jaws, so detached the bones of the face that the latter moved up and down in the act of swallowing, as though nothing held them to the head but the skin. In this case not a tooth was broken or displaced. Both this patient and the preceding one recovered.

Fractures of the upper jaw are often produced by force transmitted from the malar bone, the latter remaining sound. This portion of the face, being prominent, is likely to receive the vulnerating body first. The lines of fracture may run in various directions, into the antrum, through the nasal process, through the alveolar process, or into the orbital and palatine plates.

Being concerned in the construction of the gustatory, olfactory, lachrymal, orbital, and dental chambers, and containing numerous channels for the lodgment of blood-vessels and nerves, the superior maxillæ possess extraordinary reparative power. Mr. Hutchinson had a case in the London Hospital,* in which the entire alveolus with its teeth was completely detached, but afterwards united to the body of the bone, without subsequent necrosis. A still more remarkable instance of fracture of the upper jaw was treated in the University Hospital, London,† where the whole dental arch was separated from the bones and lay upon the inferior maxillæ: this patient recovered likewise with good union.

A lad was brought into the University Hospital, Philadelphia, who had been caught between the bumpers of two railroad-cars. The whole face was disjoined from the head. The upper jaws were greatly comminuted, the inferior maxilla was broken into four pieces, and a number of ragged wounds involved the soft parts of the face. Notwithstanding this extensive mutilation, all the fragments of the upper jaw united; a portion of the lower maxilla, being in a great measure detached from the bone, became necrosed and was removed. The deformity remaining after recovery is well represented in Fig. 630.

Fig. 630.

Appearance after recovery from an extensive fracture of the bones of the face accompanied by several wounds of the soft parts.

The two upper maxillæ are occasionally separated from each other in the line of the intermaxillary suture. It is often impossible to re-adjust such a fracture, and the violence producing the disjunction may even prove fatal; though a case of this kind which came under my observation, in a child two years old, recovered without any very evident deformity.

The bones most likely to participate in fracture of the superior maxilla are the malar, the nasal, the palatine, and the pterygoid process of the sphenoid.

Treatment.—A cardinal principle to be observed in the treatment of all fractures of the upper maxilla, one which has received the sanction of the most eminent names both in this country and abroad, is to preserve and replace all fragments and splinters, the tendency to heal in this bone being

* Medical Circular, February, 1867.

† British and Foreign Quarterly Review, October, 1860.

stronger than in the other bones of the skeleton. When a portion of the alveolus is broken away, either from its inner or its outer wall,—an accident quite common under the old system of extracting teeth by the key,—no dressing is demanded. The patient is to avoid chewing any hard substance until the detached fragment has contracted an attachment to the bone. It may happen that the separated piece will die: if so, as soon as it is sufficiently loose it should be removed with a pair of bone-forceps.

When the alveolar process is broken into two or more fragments, the pieces must be pressed into place and the jaws closed, so that the lower dental arch may serve as a support for the fracture. To maintain the apposition, a Barton or a Gibson bandage should be applied. (See Figs. 636 and 637.) If the tendency to displacement persists, we may apply fine wire to the teeth; and, if this fails, resort should be had to an interdental splint. This may be constructed of gutta-percha. I have used for this purpose, with great advantage, a piece of cork with a groove cut in its upper and lower surfaces, the one to receive the teeth of the lower jaw on the side of the fracture, thus preventing its displacement, and the other to receive the teeth of the upper jaw; I have then bound both together with a roller, as in fractures of the inferior maxilla. Should the teeth be loosened and partially dislocated, they must be pressed back into the alveoli, in the hope that they may be preserved.

When the nasal process is broken, a director applied through the nose will serve to elevate any depression which may exist.

When the wall of the antrum, which supports the malar bone, is broken in, efforts should be made to correct the displacement, as the deformity due to the depression of the malar bone, if not remedied, will greatly change the appearance of the face. To effect this, the finger may be carried into the mouth, as directed by Hamilton,* and made to act on the zygomatic process of the malar bone; or the elevation may be accomplished by introducing a strong hook under the same process through an incision made at the anterior edge of the masseter muscle.

The same author speaks in commendatory terms of a screw elevator, which is applied by making an incision over the malar bone, then screwing the instrument into its structure, and using it as a means of raising the depression.

Complications.—When the fracture is through the nasal process or involves in addition the nasal bones, there may be such a laceration of the soft parts as to be followed by emphysema of the face. This will either subside spontaneously, or may require for its removal some gentle pressure by a compress and bandage, or the free use of collodion, as recommended by Heath.†

As the nasal process contributes a part in the formation of the lachrymal canal, its fracture may entail inflammatory disease of the sac, and subsequent obstruction to the passage of the tears. Under such circumstances the treatment applicable to stricture and fistula of the lachrymal passages will be demanded.

As the infra-orbital nerve traverses a canal in this bone, it is liable to be injured, especially in fractures near the orbital plate, and this injury will give rise to neuralgic attacks or to sensory paralysis. When the painful condition can be traced to a mechanical cause, such as pressure, nothing will avail but the excision of the offending portion of the bone or of the nerve beyond the limits of its injury.

Hemorrhage.—This may come from the vessels of the soft parts, as the facial artery, or from those of the bone, principally from branches of the internal maxillary. Secondary hemorrhage in injuries to the bones of the face was of frequent occurrence during our late war, and in many instances proved fatal. To control this complication, the primitive carotid was ligated in thirteen cases,‡ five of which proved successful. When the bleeding comes from the facial artery, or from one of its branches, the vessel should be sought for

* Fractures and Luxations, p. 104.
† Injuries and Diseases of the Jaws, p. 57.
‡ Medical and Surgical History of the War of the Rebellion, Part I., Surg. Vol., p. 367.

and secured. When the hemorrhage comes from the bone, and does not cease after a reasonable time, we have but two resorts,—either the ligation of the carotid or the use of the actual cautery. It is by no means conclusive to my mind that the first is the better method. The collateral routes will very soon conduct the blood into the channels above the ligature, when the hemorrhage will be renewed. At all events, I do not believe it should be our first resort. It would be better to excise a portion of bone along the side of the fracture, and in this manner seek for the bleeding point or points and apply the actual cautery.

Necrosis.—When the comminution is extensive, some of the splinters may die; and as soon as their separation is ascertained they should be picked away with the forceps.

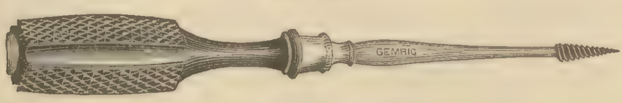
Fractures of the Malar Bone and Zygomatic Arch.—The malar bone, though much exposed, possesses great power of resistance, and will, as we have learned, sometimes transmit a force which may be applied to its body with sufficient intensity to break the upper maxilla, while sustaining no damage itself. The soft parts over the bone are likely to be contused, or they may be divided like an incised wound, and soon become much swollen. Unless the antrum is broken into, there will not be much displacement. Severe pain may follow injury to this bone, in consequence of the damage inflicted upon the temporo-malar nerve-filaments which traverse its structure. The fracture may involve its body or processes, and the force producing it may be propagated with such violence to the brain as to be followed by serious central concussion.

From experiments which I have made on the cadaver, there is reason to believe that the zygomatic process is the part of the bone which is commonly broken. In four successive fractures which I produced by the application of force to the prominent part of the cheek, it was not only this process which gave way, but in each instance the fracture passed into the orbit, terminating in the sphenoidal fissure. Very recently I witnessed a fracture of the zygomatic process, produced by a cricket-ball, which extended back along the floor of the orbit.

Symptoms.—The signs of this accident are pain, discoloration, possibly mobility and crepitation, and some degree of deformity. Extravasation of blood at the outer canthus of the eye is frequently present, and if the fracture runs into the orbit, implicating the infra-orbital branch of the fifth pair of nerves, there may be a loss of sensation in some of the anterior teeth, in the gums, and also in the alæ of the nose, together with a portion of the face adjoining.

Treatment.—If there is displacement, it must be corrected by pressure applied inside of the mouth or outside of the cheek: this will most likely prove effective if the zygomatic process has been broken. If the body of the bone is depressed, which implies also a broken antrum, the screw elevator (Fig. 631), bored into its substance, will be the most convenient method of

Fig. 631.



Screw elevator.

restoring it to the proper position. Should an external wound exist, we may be able to reach the depressed bone through the antrum with an elevator, and raise it to the proper level. When no displacement exists, nothing is required but to keep the parts covered with a lotion of lead-water and laudanum.

The zygomatic arch is sometimes broken; but the accident is rare. Malgaigne* states that he never had seen an instance of the injury, and had

* Treatise on Fractures, Packard's trans., p. 289.

been able to collect only five cases. Two examples of this accident I witnessed on the same day.

The force which determines a fracture of this arch will generally be a direct one, and the part which yields is usually that on the temporal side of the suture. This part of the arch belongs to the temporal bone, and is much weaker than that part derived from the malar. Hamilton found the temporal portion to give way in those fractures of the zygoma which he produced on the cadaver;* and my own experiments have yielded a similar result. These accidents have been followed by death, in consequence of injury communicated to the brain.

Symptoms.—Unless there is deformity or irregularity, it is difficult to affirm the existence of such a fracture. The swelling and contusion of the soft parts conspire to mask the condition beneath. Unusual movement and crepitus may be detected when the zygomatic arch is firmly pressed by opposite forces, yet the margins of the fracture, which runs usually in a transverse direction, may so interlock by their irregularities as to render the bone immovable. When we consider the anatomical connections of the zygoma, it will be apparent that it can rarely be displaced, except in two directions, viz., inwards and outwards. To its upper edge is attached the strong temporal aponeurosis, and to its lower border the masseter muscle, structures which prevent either upward or downward displacement. In most cases, therefore, the force, operating from without, will drive the arch inwards, thus giving rise to some depression. Duverney† relates an instance in which the violence was applied from within, thus forcing the arch outwards. Packard records the case of a sailor admitted to the Pennsylvania Hospital,‡ whose zygomatic arch had been broken some time before, by a chain falling on his head and shoulders, and which had united with a convex deformity.

Should the fracture be much depressed, a fragment may penetrate the tendon of the temporal muscle and disable the movements of the lower jaw, causing at the same time much irritation and pain.

Treatment.—Should the arch be broken without displacement, it will only be necessary to apply an anodyne lotion over the part, and to secure quiet to the masseter muscle: the jaws should be bound together with a Barton or a Gibson roller. When there is depression, the question of interference will depend upon the urgency of the symptoms. If the temporal muscle is not injured, the case may safely be left alone, as when the fracture is near the middle we have no means of elevating the arch without an external wound. Should, however, this muscle be penetrated or compressed,—a circumstance certainly of extreme rarity,—it would be proper to introduce an elevator through the external wound, if one exists, and, conducting it beneath the bone, raise the latter into place. When no wound is present, an incision must be made for the lever. When such an incision becomes necessary, it should be carried along the lower rather than along the upper margin of the zygomatic, as was done by Ferrier;§ and although a few muscular fibres belonging to the masseter must be cut, yet we shall have a dependent wound for the escape of any collections of blood or of pus which may follow the operation.

If the displacement is outwards, external pressure will correct the deviation. The necessity of confining the jaws together after such fractures is as imperative as in similar injuries of the other bones of the face.

Fractures of the Inferior Maxillary Bone.—These fractures occur about as often as fractures of the ulna,—that is, as compared with fractures in other bones, in the ratio of 2.4 per cent. In the Pennsylvania Hospital 209 cases were treated during a period of forty-four years.

These fractures are produced by direct force, applied either to the side of

* Fractures and Luxations, p. 106.
† Bulletin de la Société Anatomique, 1810, p. 138.
‡ Malgaigne on Fractures and Luxations, Packard's trans., p. 289.
§ Bulletin des Sciences Médicales, tome x. p. 160.

the bone or upon the chin. A blow from the fist, falls upon the face, a kick from a horse, are among the most common causes of the injury.

They are divided into fractures of the *body, ramus*, and *processes*.

When involving the body, they may be situated at any point from the angle to the symphysis of the bone. They may extend through the entire thickness of the bone (Fig. 632), or may be confined to the alveolar process. Though the presence of an opening or wound communicating with the mouth renders these fractures compound, yet this does not necessarily prolong the treatment or induce a tedious suppuration, as in compound fractures of other bones.

FIG. 632.

Fracture through the body of the inferior maxillary bone, near the anterior dental foramen.—Malgaigne.

FIG. 633.

Double fracture of the inferior maxillary bone.—Malgaigne.

Double (Fig. 633) and triple fractures are quite common. Hamilton,* in a collection of 33 cases, found 13 broken at two or more points; 19 of the 33 were comminuted. Mr. Poland had a case,† at Guy's Hospital, in which the jaw was broken into five pieces by the kick of a horse.

Portions of the alveolus are not unfrequently broken off in the extraction of teeth: I have had occasion frequently to remove fragments of necrosed bone after such operations. There is a difference of opinion among surgeons as to the most common situation of fractures of the lower jaw. Mr. Erichsen‡ thinks that they occur generally in the body of the bone, near to the symphysis, extending between the lateral incisor and the canine tooth. The symphysis is not so commonly fractured. Mr. South§ says that between the middle of the bone and the insertion of the masseter muscle, or between the insertion of the masseter and the coronoid process, are the usual places of this fracture,—a statement which is certainly latitudinarian enough, as it includes the entire half of the bone. Holmes Coote‖ says that the usual seat of fracture is between the symphysis and the insertion of the masseter muscle, and rarely at the symphysis. Gross¶ states that the most common point is towards the anterior extremity of the bone, beginning between the first and second incisors, and next in frequency is the ascending ramus; that fracture at the symphysis is unusual, and when it does happen it is chiefly in young subjects, before the union of the two halves has taken place. Bryant** fixes the position near to the canine tooth, the weakest part of the bone. Hamilton,†† in 22 cases of fracture through the body of the bone, found 15 at or near the mental foramen. Syme‡‡ says that the fracture is usually seated opposite to the bicuspid tooth,—that is, near to the anterior mental foramen,—and is rarely met with either at the ramus or at the symphysis. Most of the cases which have come under my own observation were situated close to the inner side of the anterior dental foramen. I have seen a single case of fracture at the symphysis, in a patient nearly sixty years of age. Hamilton has collected eight cases§§ of this fracture, only one of which

* Fractures and Luxations, p. 109.
† Bryant's Surgery, p. 269.
‡ Surgery, vol. i. p. 341.
§ Surgery, vol. i. p. 579.
‖ Holmes's System of Surgery, vol. ii. p. 428.
¶ Surgery, vol. i. p. 948.
** Surgery, p. 268.
†† Fractures and Luxations, p. 111.
‡‡ Principles of Surgery, p. 178.
§§ Fractures and Luxations, p. 112.

was under ten years of age. Of 158 cases of fracture of the lower jaw admitted into the Pennsylvania Hospital, 5 were under ten years of age. As in other fractures, the largest number occur between twenty and thirty. The direction of the fracture is generally oblique; occasionally it is vertical, or it may be longitudinal in cases which involve only the alveolar process. In passing through the thickness of the bone, Malgaigne thinks the course of the fracture is oblique from without inwards, and towards the ramus. Such is very frequently the case, though the reverse is equally true,—a fact which may be corroborated by examining the specimens of the injury in any pathological cabinet. When the ramus is the seat of fracture, the course or direction of the latter may be through the angle or at a point above, and is generally more or less oblique. When the condyloid process is involved, the separation occurs through the constricted part called its neck. Fracture of the coronoid process is exceedingly rare. I have never seen a case of the kind. The great depth and sheltered situation of these processes, which are situated behind the zygomatic arches in the temporal fossa, place them far out of danger. An extraordinary case of Houzelot's is mentioned by Malgaigne,* in which both coronoid and condyloid processes were broken, together with the symphysis of the bone.

Symptoms.—Generally there is not much difficulty in determining the existence of this fracture, although when the separation is incomplete it may not be detected. There is a fixed and deep pain, which is greatly increased by any movements which disturb the quietude of the jaw, as opening and closing the mouth, swallowing, or even taking a full inspiration. In addition to pain, preternatural mobility, crepitus, and deformity are present. The mobility and crepitus are best determined by grasping the body of the jaw between the thumb and finger of one hand, and the angle or ramus with those of the other hand, and applying force in opposite directions. The deformity is twofold. The fragments not only overlap, but one rises above the other, thus destroying the continuity in the line of the dental arch. It is proper to remark here that there are natural irregularities in the line of the teeth altogether consistent with a sound state of the jaw. The direction of the fracture is rarely transverse; generally it is oblique, the obliquity being from before backwards, and from without inwards.

When the break is at the symphysis, one fragment will be a trifle higher than the other, the lower being the side on which the fracturing force was applied. This, I think, is dependent on weakness of the muscles of this side, produced by the injury.

In fractures which take place in front of the masseter muscle, the posterior fragment will generally be found exterior to the anterior fragment, especially when the line of separation runs obliquely from without inwards and upwards and backwards. Should the line of fracture run in the opposite direction, the displacement will be the reverse,—that is, the anterior fragment will assume a position external to the other.

In explanation of the overlapping, we must recognize two factors, viz., the action of the digastric muscle on the injured side, and the influence of the internal pterygoid and the external portion of the masseter muscle of the sound side, these two forces acting on the anterior fragment, whilst the internal pterygoid and the deep masseter muscles of the injured side affect the posterior fragment.

For the second change—that which results in an inequality in the horizontal planes of the two fragments—two causes are to be assigned: first, the weight of the anterior fragment, and the conjoined action of the digastric, genio-hyoid, and genio-hyo-glossus muscles on the same; secondly, the power of the posterior fibres of the temporal muscles, together with the superficial part of the masseter and internal pterygoid muscles, acting on the posterior fragment. When the body of the bone is broken on both sides, the central portion descends and recedes by its own weight and the action of the mus-

* Fractures, p. 400.

cles attached on either side of the symphysis. When the head is depressed towards the chest, this central segment will rise a little, but not to the level of the other portions of the jaw.

When the *ramus* of the lower maxilla is the part implicated, there is generally not much disarrangement of the fragments, in consequence of the two planes of muscles, the masseter and the pterygoid, covering this part of the bone, and acting as splints.

When the break occurs in the *neck* of the condyloid process, there is a deep-seated pain experienced in front of the ear, aggravated by opening the mouth and by pressure. The upper fragment is drawn forwards and upwards by the external pterygoid muscle, and by grasping the bone at the angle and moving it forwards and backwards, crepitus may be distinctly felt; if a finger be placed on the condyle of the jaw whilst this movement of the angle is made, it will be found to remain motionless. The lower fragment will be drawn up by the masseter and internal pterygoid muscles, changing the expression of the face on the affected side.

Fracture of the *coronoid* process is an accident of great rarity, and is difficult to diagnose. It may be conjectured when a finger placed over the temporal region fails to detect any movement of the temporal muscle when the mouth is opened and closed. Sanson states that this process, when broken, does not unite.

In many of the fractures of the jaw there is a considerable flow of saliva possessing a very offensive odor.

Complications.—We might suppose that the inferior dental nerve, from its position, would frequently suffer damage in fractures of this bone, and thus give rise to troublesome symptoms; and yet, on the testimony of Hamilton and others, such injury is almost unknown. Deafness, accompanied with unusual sounds in the head, has been known to follow fractures of the inferior maxilla. Rossi has observed local spasms, and Flajani general convulsions of the body, after this injury; but all such sequences are probably—as believed by Petit and others—the result of intracranial damage, rather than of accident to the jaw.

Bleeding from the ears sometimes follows this fracture, induced by the force being transmitted to the external auditory canal through the condyles of the jaw. Mr. Holmes, in 1860, spoke of a specimen in which a part of the neck of the lower jaw was driven into the external auditory canal.

Paralysis of one or more of the muscles of the face is also among the after-effects of this injury,—the result of contusion.

Swelling of one or more of the salivary glands is occasionally met with, and may end in an abscess opening into the mouth or upon the neck.

Necrosis will sometimes follow the fracture and retard the cure.

Prognosis.—Fractures of the inferior jaw usually do well. We may not be able in all cases to prevent a certain amount of deformity, such as an irregularity of the dental arch; but, even when this exists, no material inconvenience will be experienced by the patient.

Tardy union is not uncommon, but non-union is rare. I believe the saliva has some influence in producing delay in the consolidation; and the presence of the smallest necrosed fragment will defeat the healing. I have seen several cases in which from this cause the union was prevented for over four months. The greatest difficulty will be encountered in double and in comminuted fractures; and under the most skillful and ingenious management cases will sometimes occur in which a perfect cure is impossible.

Treatment.—In simple fractures of the body or of the ramus of the lower jaw, the parts, if disarranged, should be adjusted by manipulation, and the bone evenly supported, and afterwards bound securely to the upper maxilla.

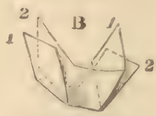
The fingers of the surgeon will accomplish the first indication. The second will be fulfilled by forming out of gutta-percha, or light binders' board, a cup-shaped splint. For this purpose take a piece of either of the above materials

four inches long and two and a half inches wide, slit it up one-third of its length from each end (Fig. 634), and cut out a concave portion from one side; fold the ends of one side within those of the other side, after it has been immersed for a short time in hot water. When dry, it will have the form of a cup (Fig. 635) for the reception of the chin, the concave side adapting itself to the convex surface of the neck. This splint is to be padded with cotton and applied beneath the chin and jaw. The third indication—that of securing the jaws together—is accomplished by the bandage of Barton (Fig. 636.) Professor Gibson employed a bandage very well adapted to effect the same ends as that of Barton. (Fig. 637.) Dr. Garretson uses a modification

Fig. 634.

Splint cut out.

Fig. 635.



Cup for the jaw.

Fig. 636.

Barton's bandage for fracture of the inferior maxilla.

Fig. 637.

Gibson's bandage for fracture of the lower jaw.

of the Barton dressing (Fig. 638), which can be loosened or tightened at pleasure without removing the entire bandage. Professor Hamilton, in the management of fractures of the inferior maxilla, employs a dressing com-

Fig. 638.

Garretson's bandage for fracture of the lower jaw.

Fig. 639.

Hamilton's bandage for fracture of the lower jaw.

posed of a firm strap, which passes from beneath the chin to the top of the head, where it buckles near to the anterior fontanelle; a second strap, made

of strong linen webbing, is looped over the vertical one of leather a short distance above the ears, and is buckled behind the occiput and over the forehead. A third strip passing over the top of the head antero-posteriorly secures the vertical and horizontal bands together. (Fig. 639.) The ordinary four-tailed sling is sometimes used in dressing fractures of this bone; but its insecurity renders it objectionable.

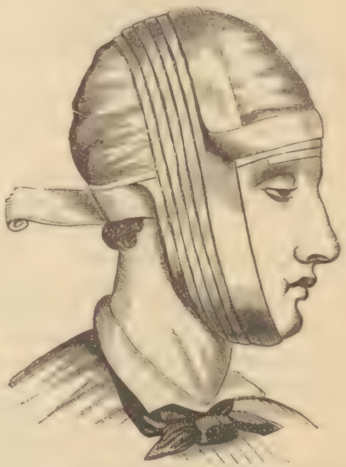
In Philadelphia, the bandage of Barton is the one generally adopted, and certainly it accomplishes as well as any other in use the twofold purpose of securing together the jaws and retracting the chin. This dressing is somewhat like that formerly used by the French surgeons. (Fig. 640.)

When the fracture is through the neck of the condyloid process, it may be necessary to modify the dressing. The upper fragment is liable to be

Fig. 640.

French apparatus for fracture of the lower jaw.

Fig. 641.



The crossed of the angle of the jaw for fracture through the neck of the condyle. The turns should exactly overlap one another.

drawn forward, upward, and inward by the external pterygoid muscles, and, as we have no very certain means, when such is the case, of restoring it to its proper functional position, the only alternative is to carry the lower fragment in the same direction, in order to effect a juxtaposition. Malgaigne was able in a case of this fracture to push the condyle back into position by means of his finger carried along the upper and lateral wall of the pharynx.

To secure the parts in place, it will be necessary to place a compress of muslin in the recess between the neck and the angle of the jaw, and apply the bandage designated the "crossed of the angle of the jaw." (Fig. 641.)

The dressings should be renewed whenever they become loose. The patient should not attempt to speak or to open the jaws.

In the course of five or six weeks the bandages may be laid aside; but the patient must be careful not to masticate any very hard substances, for fear of refracturing the bone.

We may now consider the management of cases of a more complicated and troublesome nature.

In addition to the fracture, some of the teeth may be loosened, or even entirely detached from the alveoli, and remain suspended by a shred of the gum. These should be immediately replaced, unless they happen to be in the line of the fracture, for even if they do not regain their attachment no harm can come of the attempt. Dr. Watson, of this city, had a case in which two of the incisors were driven through the bottom of the alveolus

deeply into the cancellated tissue of the jaw, where they remained without giving rise to any inconvenience whatever.

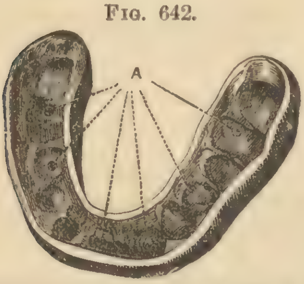
In cases of either single or multiple, compound or comminuted fractures, where the displacement obstinately persists in spite of the ordinary dressing, there are several devices in use to overcome the difficulty. Before resorting to such, the patient should be placed in bed on his back, with the head neither to the one side nor to the other, but sufficiently elevated to bring the chin well towards the sternum. Such a position will sometimes remove immediately all disarrangement of the fragments, and it should be maintained for five or six days, when the patient may again be allowed to rise, without any tendency to a return of the displacement. If, however, we are not successful by this plan in correcting the vicious tendencies of the fragments, a forced coaptation may be attempted by fastening together the teeth on opposite sides of the break. This device is as old as Hippocrates. For this purpose iron or silver wire is better than silk or hempen thread. The practice in my hands, however, has not been satisfactory. The ligatures are prone to become disarranged, to make the gums sore, and even to loosen the teeth.

A second mode of maintaining the apposition of the fragments is by a cap of metal constructed of silver, or of some composition of sufficient resistance to be fashioned into a cap, which is made to bridge over the fracture and rest upon the teeth on either side.

A third device is the use of what are called interdental splints. These are made of vulcanized rubber or of metal. The most elaborate are those of Gunning and of Kingsley, of New York, and that of Dr. Bean,* of Atlanta, Georgia. In the preparation of these splints an impression is first taken of the teeth, both of the upper and of the lower jaw. The fragments of the broken bone are to be taken separately. The impression is made in wax, which serves as a pattern for a plaster cast, from which the vulcanite is subsequently fashioned.

Among the simplest of Gunning's splints are the forms shown in Figs. 642

FIG. 642.



Gunning's interdental splint: *A* points to the perforations for injecting water.

FIG. 643.

Gunning's interdental splint.

and 643, which receive all the teeth of the lower jaw, extend a short distance over the gum, and have perforations through which to throw a stream of liquid for the purpose of cleanliness. This splint, when placed in position, forms a cap, and is kept in place by securing the jaws together with a bandage, or by means of screws passed between the teeth.

A third splint of Dr. Gunning's, one which he uses in cases where the teeth have been lost, is formed by connecting steel branches with the interdental part of the apparatus, of which the upper branch passes along the superior part of the face, and the lower one along the outside of the lower jaw; these are kept in place by three bands, one being placed at the chin in order to hold the jaw up in the splint, one running from the metal band to

* Richmond Medical Journal, February, 1866.

the back of the neck, and one passing to a cap which is worn over the head, and with which the splint is connected. (Fig. 644.)

Kingsley, of New York, a very ingenious dentist, forms a simple splint from vulcanized rubber. In its preparation an impression of both jaws is taken in plaster,—the lower jaw with its deformity or displacement. The impression of the latter is divided at the place of fracture, and then united so as to conform to that of the upper jaw. From this mould of the lower jaw the rubber is fashioned into the proper form: from it pass steel rods of light wire one-sixteenth of an inch thick, which, when the splint is introduced into the mouth and adjusted, run from the corner of the mouth along the side of the cheek, terminating in front of the ear. (Fig. 645.) When applied, the teeth occupy the cavities in the splint, the latter being kept in position by a strip of roller passed beneath the chin from one arm of the apparatus to the other.

Fig. 644.

Gunning's interdental splint.

The splint of Dr. Bean resembles closely that of Dr. Gunning, and is well suited for the treatment of comminuted fractures of either jaw. It is constructed of vulcanized rubber, and is fitted to the teeth of both the upper and the lower maxilla, by an impression previously taken in wax. (Fig. 646.) The splint, when applied, is kept in position by straps which pass over and around the head, and also behind the neck. (Fig. 647.) During the late war Dr. Bean had charge of a hospital at Macon, Georgia, especially set apart for injuries of the jaws, in which over forty cases, attended with peculiar complications, were treated with the most satisfactory results.

Fig. 645.

Kingsley's interdental splint.

It will be perceived that all these splints must have a limited value, as their construction requires a degree of manual skill not generally possessed. In cities or towns where the services of an intelligent dentist can be commanded, their value in many instances cannot be over-estimated.

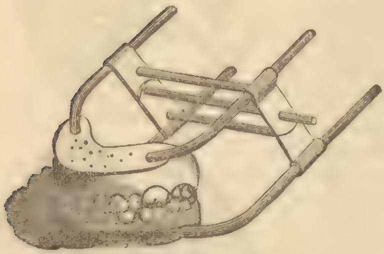
Professor Hamilton, in 1849, introduced to the notice of the profession* a method of preparing gutta-percha for interdental appliances which places them within the reach of every one.

He directs that pieces of the gum be immersed in hot water, and, when well softened, moulded into wedge-shaped blocks. These are carried between the back teeth on each side of the jaw, observing to bring the pieces on the side of fracture sufficiently far forward to include the line of fracture. After these pieces are adjusted, the fingers are placed under the body of the jaw, pressing it firmly up, closing the mouth, and imbedding the teeth

* Buffalo Medical and Surgical Journal, vol. vi. p. 144, August, 1849.

in the plastic gum. The fingers passed along the base of the jaw will ascertain if the line is uniform or if the fragments are on a level. A few minutes

Fig. 646.



Bean's interdental splint.

Fig. 647.

Bean's splint applied.

will suffice to harden the gum, when the mouth may be opened, and the splints removed and turned into shape, after which they can be re-inserted and the jaws bound together with one of the dressings already described.

In certain cases of unmanageable displacement, the fragments have been drilled and secured together by silver wire. A case of this kind is reported by Kinloch, of Charleston,* and another by Hamilton.† In the last the bone was broken during the operation of trephining: the wire was introduced at once.

By means of a delicate drill and silver or iron wire, the coaptation may be quickly effected, and when the usual resources at the command of the surgeon have been exhausted, this plan may be adopted without hesitation. In applying this suture, a deep hold should be taken in the bone, as I have seen the wire cut out in a few days when this precaution has been neglected.

Should there be much contusion of the soft parts, a water-dressing will answer the best purpose, to which may be added laudanum in case the patient experiences severe pain. If an external wound exists, it should be closed with the silver suture.

When the secretions which empty into the mouth become offensive, the patient may use, with great advantage, some deodorizing fluid, two or three times a day. The permanganate of potash, carbolic acid, and the chlorinated washes are too repugnant to the taste. The wash which I prefer is a decoction made from the berries of the Rhus glabrum, to which may be added chlorate of potash, with a little tincture of myrrh.

The food of the patient should consist of liquids, such as milk and nutritious broths, which can in almost all cases be readily drawn into the mouth through the apertures between the teeth. Cases have occurred in which this could not be done: under such circumstances it would be proper to resort to an interdental splint, the simplest being the rubber wedges of Hamilton, already described.

Delayed Union.—Should the bone fail to unite, we must endeavor to excite the parts by a local stimulus. The ends of the fracture may be violently rubbed against each other. In two cases I succeeded in securing union by boring into the ends of the fracture with an awl-shaped drill and afterwards putting the jaw up in a Barton bandage. Physick introduced a seton between

* American Journal of the Medical Sciences, July, 1859.
† Fractures and Luxations, p. 120.

the fragments. In a case reported,* the seton was allowed to remain three months, and the cure was complete. A third method consists in drilling and wiring the fragments together,—a plan both simple and efficacious. If the case is one of long standing,—ten or twelve months,—a thin-bladed knife should be passed between the contiguous surfaces of the fracture, to divide any cartilaginous incrustation, before using the drill. Premature operations, however, are to be deprecated, as fractures of the inferior maxilla may, like fractures in other bones of the skeleton, in some instances be very slow in uniting, and yet may ultimately consolidate under the ordinary dressings. In this way I have succeeded in establishing firm union of the lower jaw where the fragments have remained movable for a period of four months.

The state of the general health must not be overlooked in these cases of delayed union, and where any retarding cause of a constitutional nature can be ascertained, it should, as far as possible, be removed.

Gunshot Wounds of the bones of the face produce the greatest comminution and subsequent deformity. The general rules to be observed in their management are the following:

First. Control of hemorrhage, if any be present.

Second. The removal, as far as possible, of the vulnerating body, either through the mouth or through the face, as is most convenient.

Third. The dressing of the wound.

Any fragments of bone which are not entirely detached should be preserved. This injunction is less important in fractures of the lower jaw than in those of the upper.

Fractures of the Hyoid Bone.

Sheltered as the hyoid bone is by the lower jaw, it is seldom the subject of fracture; yet we have quite a number of such accidents recorded. A single author† has collected the histories of thirteen cases.

The cause of this fracture is generally constriction of the neck by a cord, as in hanging, or by the grasp of the hand, as when a person in a quarrel seizes an antagonist by the throat. A blow or a fall upon the front of the neck may produce a similar effect.

Hamilton, in an analysis of ten cases,‡ found that three were produced by hanging, three by grasping the throat between the thumb and fingers, three by blows or falls upon the front of the neck, and one by muscular action. Malgaigne gives an instance of a fracture of this bone by the last-named cause; at least it was so believed by Ollivier of Angers, from whom he quotes.

When produced by hanging, the fracture appears to take place in the body of the bone, but when caused by the grasp of the hand, the cornua generally suffer. The latter is easily understood, as the force presses the horns of the bone towards each other; but why the body should yield first in persons who are executed by hanging is not so readily explained.

Symptoms.—There is pain in the submental region, aggravated by movement of the neck or of the tongue. Thus, in swallowing, speaking, or even opening the mouth, the suffering is so acute that the patient avoids every motion of the kind. The relation and the anatomical connections which exist between the pharynx and the larynx are such that the former cannot move without affecting the latter: so that the patient may be entirely unable to swallow. Again, the contiguity of the cornua and the body of the hyoid bone to the opening of the larynx is such that the inflammatory swelling following such an accident may embarrass the respiration and threaten suffocation. Preternatural mobility and crepitus in some cases will be recognized, though in others these signs may be absent or may escape detection. Sometimes the patient, in an attempt to swallow, will feel crepitus when it

* Philadelphia Journal of the Medical and Physical Sciences, vol. v. p. 116.
† G. D. Gibb, M.D., Diseases and Injuries of the Hyoid Bone, London, 1862.
‡ Fractures and Luxations, p. 136.

cannot be heard. Displacement can be best detected by introducing a finger into the pharynx. The injury may be attended with a discharge of blood from the fauces, and after a time ecchymosis will appear in the subcutaneous tissue of the neck.

Prognosis.—Although the fixation of the fracture must be, in a great measure, impracticable, yet, unless there is some complication in the shape of damage to the larynx or in the formation of an abscess, a favorable result may be expected. Should a portion of the bone impinge upon the entrance of the larynx, the patient's life might be jeopardized. A case has been recorded in which death followed a fracture of the hyoid bone, through one of its great horns being thrust between the epiglottis and the rima glottidis.* The displaced horn produced a harassing cough and hectic fever, which finally wore out the patient. Malgaigne mentions a case related by M. Ollivier,† in which the great horn, after its fracture, became necrosed, and was finally discharged through a sinus in the neck, the patient recovering with a subsequent difficulty in deglutition.

Treatment.—If there is displacement, an attempt should be made to correct it, and this can only be done by operating with one finger in the pharynx and the other on the outside of the neck, in this manner pushing the detached fragment outward and forward, and afterwards endeavoring to maintain the adjustment by position and absolute quiet. The patient must abstain from opening the mouth, from speaking, and from swallowing. If we consider the anatomical relations of the great horn of the hyoid bone, we shall see that, aside from the fracturing force, there is only one muscle favorably situated to produce displacement, and that is the middle constrictor of the pharynx. The great horn is suspended between the thyro-hyoid muscle and ligament below, and the hyo-glossus muscle and digastric aponeurosis above; and these constitute mutual checks to either upward or downward displacement. The middle constrictor, however, passing forward, downward, and a little outward, will, when the separation of the horn from the body takes place, draw the former upward, backward, and inward. In view of these facts, what position secures the best adjustment? On this subject there is some difference of opinion among writers. The one which I regard as best calculated to approximate the fragments is that in which the head occupies its natural position in relation to the neck,—that is, neither extended nor flexed.

As articulation and deglutition are both acts which favor displacement, the patient must not speak, and for the first three or four days should be nourished by nutritious enemata. After this, liquids may be taken by the mouth, and if the suffering in swallowing is great, resort may be had to the œsophageal tube to convey food into the stomach.

Inflammatory symptoms must be combated by leeches and anodyne lotions, and if any mechanical obstruction to the entrance of air into the larynx should threaten suffocation, tracheotomy or laryngotomy will be demanded.

Fractures of the Cartilages of the Larynx and Trachea.

The cartilages of the larynx are not often broken, but, when the accident occurs, the danger to the life of the patient is most imminent. As these cartilages undergo ossification in advanced life, the presumption would be that such injuries occur only in aged persons; but the cases recorded lead to a different conclusion. Dr. William Hunt, in his valuable paper on this subject,‡ gives five cases occurring in childhood; and of the twenty-nine reported, as far as could be learned, fifteen of the patients were not over fifty-five years of age.

Although all the cartilages, and sometimes the trachea in addition, are broken, yet the thyroid, from its prominence, is most frequently damaged;

* British and Foreign Medical Review, 1851, vol. viii.
† Malgaigne on Fractures and Luxations, Packard's trans., p. 328.
‡ American Journal of the Medical Sciences, April, 1866.

next in order is the cricoid. The table of Hénoque,* with the ten cases of Durham, exhibits, in the sixty-two examples of laryngeal fractures, twenty-four of the thyroid and eleven of the cricoid cartilage.

Causes.—The same causes which produce fracture of the hyoid bone will break these cartilages, such as blows on the front of the neck, violent compression of the neck by the grasp of the hand, or by a cord, in suicidal attempts. If the parts become displaced, the most urgent symptoms arise.

Symptoms.—There is pain, followed by rapid swelling and deformity of the neck. Sometimes there is an unusual prominence, at other times a flattening, of the larynx,—the difference being determined by the manner in which the fracture is produced. When caused by a grasp, thus pressing the alæ of the thyroid cartilage towards each other, there will be a prominence; if, on the other hand, the injury is inflicted by a blow applied in front, the deformity will consist in flattening. Bloody expectoration, emphysema of the neck, and alteration or entire loss of the voice, are present. The respiration and deglutition become difficult. Dyspnœa is among the most common phenomena of the injury. In seven out of the nine cases recorded by M. Cavasse it existed. In a case which I saw with Dr. Hunt it was urgent, and it was also present in the instance narrated by Stokes, of Dublin.† In some cases the tongue becomes swollen and protrudes from the mouth. Ecchymosis, mobility, and crepitation are also among the signs of the accident. Often the swelling is so great that the last two symptoms cannot be detected. The obstruction to the respiration is accompanied by lividity of the face, a feeble and frequent pulse, and a cold perspiration.

The extravasated blood which follows the injury may be subcutaneous, or beneath the deep cervical fascia, or submucous; or it may be in all these situations at the same time.

When the dyspnœa comes on immediately after the accident, it is due either to extravasated blood or to displacement of the fragments of the cartilage; and when it appears later, it can only be referred to serous effusion or to inflammatory swelling.

Prognosis.—The surgeon should regard every case of fracture of the larynx as an injury of the most serious nature, and should be exceedingly cautious and reserved in venturing an opinion as to the final result. Even though none of the urgent symptoms detailed may be present, the results of the subsequent inflammation may quickly change the entire aspect of the case. Of the sixty-two cases collected by M. Hénoque, fifty proved fatal and twelve recovered: of the twenty-seven cases analyzed by Dr. Hunt, ten recovered and seventeen died.

Treatment.—Where the case is one of simple fracture, without bloody expectoration, dyspnœa, or other urgent symptoms, the treatment will consist in enforcing absolute silence, as all movements of the tongue tend to displace the fracture. The patient is to abstain from swallowing; but pieces of ice may be allowed to melt in the mouth. He should be nourished for the first few days by the rectum, using milk and beef essence as enemata. If inflammatory symptoms arise, leeches must be freely applied to the neck; and to relieve pain and nervous excitement either hypodermic injections of morphia or suppositories of opium can be exhibited. Our great resource, however, is tracheotomy; and whenever emphysema and bloody expectoration appear, the operation should be done without delay. Dr. Hunt states that there is no instance of recovery on record, without opening the windpipe, when these symptoms existed. Of the eight operated on, six recovered and two died; four got well by antiphlogistic treatment; these, however, were separations in the median line, and had neither bloody expectoration nor emphysema. After the introduction of the tracheal tube, the surgeon should, as far as possible, correct any displacement which may exist, by carrying a director through the trachea, when inflammation is not present; should this fail,

* Holmes's System of Surgery, vol. ii. p. 462.

† Dublin Quarterly Journal of the Medical Sciences, May, 1869, p. 307.

he is justifiable in separating, by incision, the alæ of the thyroid cartilage for that purpose, if there is ground for believing that the cavity of the larynx is seriously encroached upon. The patient may, after tracheotomy, be allowed to swallow nutritious liquids by the mouth.

Unpromising as a rupture of the trachea may be, yet such an accident is not altogether hopeless. Mr. Long, of Liverpool,* relates the case of a laborer who had his trachea divided by the coupling irons of two railroad-carriages, inflicting at the same time an external wound. By frequently sucking the blood out of the trachea by means of a long canula, the man recovered, the gap, it was believed, being filled with connective tissue, arranged so as to form a tubular communication between the ends of the trachea for the passage of air.

FRACTURES OF THE BONES OF THE CHEST.

Fractures of the Ribs.

Malgaigne alleges that solutions in the continuity of the ribs are the most common of all fractures.† At the Hôtel-Dieu they amount to one-ninth of the whole number treated. Poland‡ claims about the same proportion for those received into Guy's Hospital. Of 2275 fractures treated in that institution during a certain period, 222 were fractures of the ribs. I doubt very much if so large a proportion is met with in American hospitals. Among the 2208 fractures treated in the Pennsylvania Hospital during twenty years, and tabulated by Norris,§ there were 88 fractures of the ribs; and of the 6480 comprised in the collection of Willard, from the same institution, 221 were fractures of these bones.

No age can be said to be exempt from this accident, although it is most common to persons in middle and in advanced life. In the young, the great mobility and elasticity of the thoracic walls constitute an important protection against fracture. The ossification of the cartilages, and the fatty degeneration which the costal pieces undergo in the aged, render them less able to resist injury. The majority of cases which have come under my own observation have been in persons of mature life. Males suffer oftener than females.

These fractures are either *complete* or *incomplete*. The former are sometimes called fissures. Even in a complete fracture the periosteum may not be severed.

Causes.—The causes which produce fracture of the ribs are numerous: among the factors may be mentioned falls, blows, kicks from horses, the passage of wagon-wheels over the body, the falling of earth-banks, and extreme pressure and counter-pressure. Cases are recorded in which muscular action, as in the act of coughing, was sufficient to produce this injury. Malgaigne has collected seven instances of this kind.‖ Nancrede met with a case of fracture of the second rib, in a gardener, brought to the Episcopal Hospital, in this city, which was produced by muscular effort in straightening a scythe-blade.¶ There was probably some defect in the bones of these patients, rendering them preternaturally brittle. The causes which operate to produce a fracture of the ribs act either laterally or antero-posteriorly. If in the first direction, as when the wheel of a loaded wagon passes over the side of the chest, or the body falls violently sidewise against some projecting object, the fracture will take place near to the point where the force is applied. If the violence is applied after the second manner, that is, antero-posteriorly, thus forcing the sternal and vertebral ends of the rib towards each other, thereby increasing the convexity, the fracture will take place near the summit of the

* Medical Times and Gazette, July and October, 1856.
† Treatise on Fractures, Packard's trans., p. 346.
‡ Holmes's System of Surgery, vol. ii. p. 554.
§ Contributions to Practical Surgery, p. 143.
‖ Treatise on Fractures, Packard's trans., p. 348.
¶ Philadelphia Medical Times, May 23, 1874, p. 535.

arch, or remote from the place where the force is applied, constituting an "indirect fracture." In fractures caused by direct force, the internal surface of the bone first gives way, while in those produced by indirect force, the external fibres of the rib yield first. There is a difference of opinion as to the most common seat of costal fractures. Malgaigne states that the anterior third is the part most commonly broken. This does not accord with my observation, in regard either to cases treated or to cabinet specimens which I have examined, the great majority of which have been on the vertebral side of the middle (Fig. 648), or somewhat anterior to the angle of the bone. Second in order of frequency come fractures at the anterior third.

Fractures may occur simultaneously on both sides. Certain ribs, by reason of their situation, as the first and the second, being protected by the clavicle,

Fig. 648.

Fracture of a rib at its vertebral and also at its sternal extremity.

are rarely broken; others, like the eleventh and the twelfth, from their mobility, escape injury. The series between the third and the eighth are those most exposed to fracture. Sometimes two or more breaks are met with in the same rib. The direction of the fracture may be transverse or oblique, although in gunshot injuries it is sometimes longitudinal.

The displacement may be inward or outward,—inward when the fracturing cause has been direct, outward when indirect; though, as a general rule, there is not much disarrangement of the fragments. This fact is attested by most of the museum specimens of this injury. Vertical displacement of broken ribs is counteracted by the intercostal muscles and aponeuroses; overlapping, by the decussation of the fibres of the same muscles, and by the fixed condition of the vertebral and sternal attachments of the bone. Displacement in the axis of the rib is prevented by diminished activity in the respiratory movements of the thorax after this injury.

Complications.—These fractures may be complicated by rupture of some of the fibres of the great pectoral or of the external oblique muscles; by the presence of an external wound, constituting a compound fracture; by lesion of the pleura, exciting pleuritis; by injury to the lung, producing hemorrhage, pneumonia, or emphysema; by laceration of the intercostal vessels, followed by hemorrhage; by damage to the intercostal nerve, exciting neuralgia; by injury to the pericardium and heart;* by asthma or any chronic cough; and, lastly, by injury to the diaphragm or to the contiguous abdominal viscera. The proportion of complicated fractures is well shown in Guy's Hospital Reports for 1860, vol. vi., where 136 cases are recorded, of which only 28 were complicated, and 16 of these were rendered so by the occurrence of emphysema. Of 221 cases of this fracture brought into the Pennsylvania Hospital, only 8 were complicated.

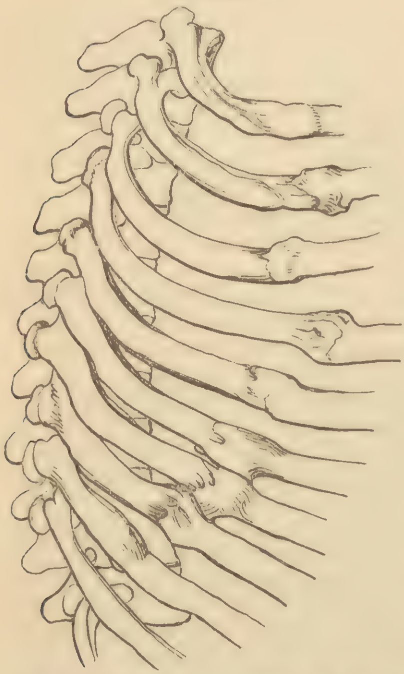
Symptoms.—A patient with fractured ribs complains of pain at the seat of injury, which is greatly intensified by any attempt at full breathing. On this account he avoids, as much as possible, using the thoracic muscles of respiration, accomplishing the work by means of the diaphragm and abdominal muscles. If asked to make a full inspiration or to cough, these acts are abruptly stopped by a severe stitch, and in making the attempt the patient will perhaps feel the grating of the broken ends of the bone. Crepitation,

* Chelius's Surgery, vol. i. p. 599.

which is the most reliable sign, may be ascertained either by placing the hand over the seat of injury, and then directing the patient to attempt a full inspiration or a prolonged expiration, or by the ear being placed over the part during similar movements. Unusual movement and crepitus may occasionally be recognized by placing the fingers on the sternal and vertebral sides of the suspected point of injury, and alternating the pressure. When the lung is wounded, the injury will be indicated by an emphysematous state of the cellular tissue over the exterior of the chest, which may be known by the peculiar crackling or crepitation felt and heard when the skin over the thorax is pressed upon. When the lesion of the lung is deep, hæmoptysis will be present.

PROGNOSIS.—In uncomplicated cases the prognosis is always favorable. The union of the fragments is accomplished in about one month. A few examples of ununited fractures are recorded. Malgaigne furnishes one in which there existed a capsular ligament lined with a synovial membrane.* A singular specimen is in the museum of the College of Surgeons, England, in which a mass of callus envelops the broken ends, holding them together, although no union has taken place at the extremities of the bone.† Bridges of bone sometimes extend from one rib to another. (Fig. 649.) There is always present an ensheathing callus, which will be found to be very smooth and small in quantity on the inner side of the fracture.

FIG. 649.



Fracture of ribs, with ensheathing callus and with bridges of bone uniting adjoining ribs.—Malgaigne.

In complicated cases the prognosis will depend on the organ involved and the extent of injury sustained. If the pericardium or heart is wounded, death will quickly follow. A slight injury to the pleura, producing traumatic pleurisy, is not often serious, as the inflammation is usually quite circumscribed, and ceases on the removal of the cause. Should we be unable to correct the displacement which produces it, the result may prove unfavorable. If the lung is wounded, there is always cause for anxiety. When the lesion consists only of a scratch, it does not seriously complicate the case; but when the organ is penetrated by one of the fragments, the worst consequences may be apprehended. Should the patient not perish from hemorrhage, the risks of pneumonia or of abscess remain to be encountered.

When the chest has been subjected to great violence or to concussion, the patients may die in a state of profound collapse.

Of 28 cases of fractured ribs treated in Guy's Hospital and complicated by lung injuries, Mr. Bryant informs us that 8 died. The mortality attending all fractures of these bones, as derived from the statistics furnished by the Pennsylvania Hospital, will be seen by a reference to the table, namely, 32 deaths in 309 fractures.

A wound of the intercostal vessels may be considered a grave complication, especially when produced by a gunshot. Of 15 cases of this injury reported during the War of the Rebellion, 11 died. As much as four pounds

* Treatise on Fractures, Packard's trans., p. 353.
† Holmes's System of Surgery, vol. ii. p. 559.

of blood was found in the chest in one instance following an injury of these vessels. Should the diaphragm be impaled by the broken bone and an abdominal viscus be injured, a fatal result may be looked for.

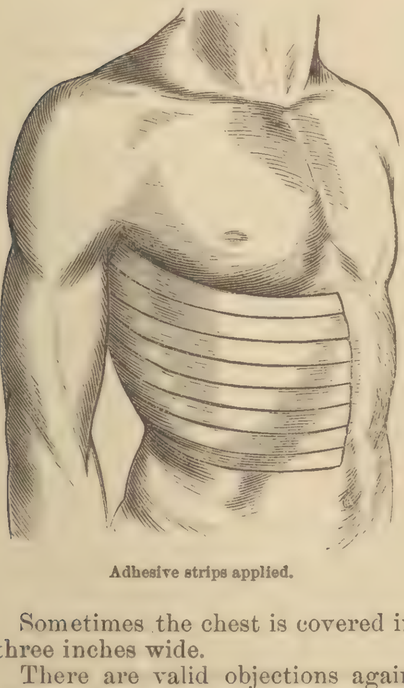
A traumatic pleuritis, or a pneumonia, which may follow a fracture of the ribs is generally local, and by no means so grave, in my experience, as the same affection when arising from idiopathic influences. If the patient is aged and the subject of any pulmonary disease, such as chronic bronchitis, or asthma, and if, in addition, there is any costal displacement in the direction of the pleura, or of the lung, an unfavorable termination is probable, unless the attending cough can be controlled by the usual remedies.

Treatment.—The local treatment consists in securing quiet to the fractured rib. There are several ways of effecting this end. If called to a patient after such an injury, and before he has been removed from the place of the accident, a temporary dressing should be applied. A handkerchief for this purpose may be pinned about the chest, or the vest may be taken up with pins in such a way as to give an excellent support to the ribs. The permanent dressing may consist of adhesive strips, the plaster splint, a broad encircling bandage, or a wide roller. The adhesive plaster may be applied in one broad sheet, or, what is better, in several strips. These strips should be from two to two and a half inches wide, and long enough to extend over the affected side from the spine to the middle of the sternum. They should not only support the fracture, but should also cover two or three ribs above and the same number below the injured bones, and be applied parallel with the course of the ribs. (Fig. 650.) This method of treating fractured ribs was introduced into practice by Hannay, of England, and should take precedence of all others.

A very secure and comfortable dressing can be made in cases where a bilateral fracture of some of the ribs occurs, by first enveloping the thorax with a thin gauze flannel shirt, and afterwards surrounding it with the plaster roller.

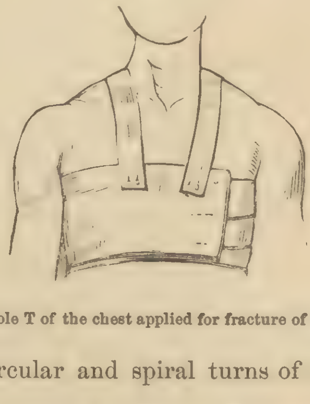
A third method consists in surrounding the chest with a broad piece of stout muslin or cotton flannel, making it secure with pins, and preventing it from slipping down by two strips passing over the shoulders and fastened to the front and back of the bandage. (Fig. 651.)

Fig. 650.



Adhesive strips applied.

Fig. 651.



Double T of the chest applied for fracture of the ribs.

Sometimes the chest is covered in by circular and spiral turns of a roller three inches wide.

There are valid objections against all plans of dressing which entirely surround the thorax. They restrain to a very uncomfortable degree the muscles of respiration, when it is desirable that they should be left free on

the uninjured side. In patients suffering from asthma, or from any disease of the lungs, the distress is peculiarly severe. Except, therefore, in cases where the ribs are broken on both sides, this mode of treatment should be abolished.

It is not necessary that the patient should remain in bed, unless the injury has been more than ordinarily severe; and when this is the case the semi-recumbent position, generally speaking, is the one which affords the most comfort. A patient will intuitively take the posture which gives the most relief.

When external displacement exists, the fragments should be pressed into place before applying the dressing. When the displacement is inward, the fragments may be sprung into position by pressing the sternum back towards the spine. The adjustment can sometimes be effected by the motion communicated to the fragments in breathing; but, as all voluntary efforts of this kind are very painful, ether may be administered. The long, full inspirations which attend complete anæsthesia constitute a powerful means of reduction. Where one fragment is depressed, Malgaigne speaks favorably of pressing the other down until it touches its fellow. Should their serrations become locked, the elasticity of the fragment pressed down, when it is released, will raise the other into position. Cases may occur, though they are certainly very rare, in which the displacement of the rib inward may create such urgent symptoms as to render interference imperative: when so, the most practical method of restoring the parts to the proper position would be to use a strong hook with a moderate curve and sufficiently sharp to penetrate the soft parts. This could be entered along the upper border of the depressed rib, in order to avoid the vessels, and then passed to its inner surface, when the fragments could be drawn out. The manœuvre is not a difficult one on the cadaver.

The existence of emphysema, which can be recognized by the crepitation or crackling on pressure, does not, in most instances, seriously complicate the case. It may be safely let alone, as the air will be gradually absorbed. If an exceptional case should occur, where its accumulation becomes so great as to produce serious embarrassment to the function of respiration, punctures might be made in the soft parts for its liberation.

Hemorrhage, when present, will result either from a wound of an intercostal vessel or from injury to the lung.

If there is an external wound, with comminution of a rib, and attended by hemorrhage, as frequently occurs in gunshot injuries, the fragments should be removed. If the fracture is a compound one, without comminution, and there is reason to believe that an intercostal artery has been torn, the vessel may be tied according to the plan directed under the head of gunshot wounds of the chest, provided the bleeding is profuse. If no external wound exists, the assumption that the hemorrhage comes from an intercostal, in any case, would be a matter of so much uncertainty as to render any operative interference improper.

Pneumonia and pleuritis are generally quite circumscribed, and yield to rest, counter-irritation, and opiates. Should they prove to be severe, local blood-letting, vesication, and external warmth will be demanded. In cases of cough, anodynes become indispensable.

Fractures of the Costal Cartilages.

Zwingle, in 1698, noticed such a fracture while making a post-mortem, and so also did Lobstein, in 1805. Magendie appears to have seen as many as five cases in two years.

These fractures are by no means common. The great elasticity of the cartilages doubtless explains their immunity, and while we would naturally expect the accident to take place in persons advanced in life, and in whom these structures were ossified, yet such is not always the case. Of the three

cases seen by Malgaigne, one was a boy of seventeen. The case given by Pyper,* of a man twenty-five years old, who had a fracture of the cartilages of the sixth, seventh, and eighth ribs, was one in which there was no ossification.

The cartilages of the seventh and eighth ribs appear to be the ones most commonly broken. The line of separation is always transverse, and the fragments are without serrations. The displacement varies in different cases. When the cartilage is broken near to the sternum, the sternal will generally be in front of the costal fragment; and when the fracture occurs near to the rib, the reverse will be true. In some instances there is no displacement whatever.

The repair of such fractures is usually by a ferule of bone, which not only surrounds the fragments, but extends between their ends. Sometimes union does not take place, and a false joint results. In St. Bartholomew's Hospital there are two specimens in which the union appears to have been effected by cartilage.

Causes.—These are of the same nature as those which produce fracture of the ribs, only intensified in violence, and hence we find, in several of the recorded cases, that severe internal injuries accompanied the accident.

Symptoms.—The signs of the accident are pain, deformity, undue mobility, and crepitation. The pain is aggravated both by inspiration and by expiration, especially when these movements of the chest are carried beyond a certain point. The deformity appears as an undue prominence, due in a measure to the elasticity of the cartilage. Both unusual mobility and crepitus can be detected by applying pressure over the seat of fracture, but the crepitus is neither so rough nor so distinct as that which results from rubbing together the ends of a broken bone.

Treatment.—The treatment does not differ from that proper in cases of broken ribs. Adhesive strips, or a compress, placed over the seat of fracture and secured by enveloping the chest with a broad bandage, answer every purpose. Malgaigne has employed a truss in cases of displacement, the pad resting over the broken cartilage and the spring passing half-way round the chest. When such fractures are kept in position, they heal in four or five weeks.

Fractures of the Sternum.

The sternum, supported as it is on the ends of elastic levers, and therefore being very movable, is rarely the subject of fracture. Some idea may be formed of the infrequency of the accident, when it is stated that only one case was admitted into the Hôtel-Dieu in eleven years. Lonsdale saw but two cases out of 1901 fractures which were admitted into the Middlesex Hospital. During five years only two cases were met with at Guy's Hospital, and but one of these was recognized during life. It is quite possible that the injury is often overlooked, a supposition which is strengthened by the statement that during four years—from 1857 to 1860—only nine cases were admitted into the wards of St. George's Hospital.† It occurred 13 times at the Pennsylvania Hospital in 8662 cases of fracture.

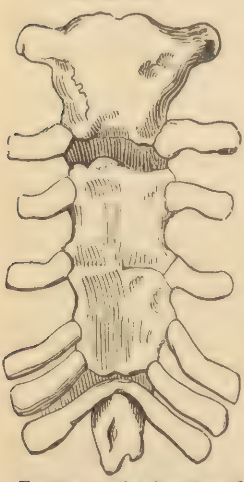
Causes.—This fracture may be produced by direct violence, as when the body is run over by the wheels of a loaded wagon, by the kick of a horse, by the stroke of a carriage-pole, or by the caving-in of an embankment. Indirect force may also produce this fracture. Numerous cases of this kind are recorded. Cruveilhier met with one in which the patient fell from a height and alighted upon his buttocks.‡ A patient was received into St. George's Hospital§ with a fracture of the sternum produced by falling headforemost from a hay-wagon and striking the ground with the

* Lancet, October, 1844.
† Holmes's System of Surgery, vol. ii. p. 563.
‡ Cruveilhier, Bulletin de la Société Anatomique, June, 1826.
§ Medico-Chirurgical Review, 1832, vol. xx. p. 536.

head bent forward. Gross* and others record cases of such fractures following falls, where the persons have alighted upon the feet. The injury may also be caused by falls on the back, as were those related by David in his "Memoir on Counterstroke," by Sabatier,† and by Rollande.‡ I cannot avoid the conclusion that in these cases there was a muscular element at work in determining the fracture, rather than the factor of indirect force. It is very difficult to ascertain with any certainty the exact position of the body of a falling man in the brief but different stages of his descent, or to estimate the almost superhuman muscular efforts made by a person under such circumstances. In all cases in which the body is greatly extended, the sternum is acted upon by forces operating at each extremity of the bone, through the sterno-cleido-mastoid, sterno-hyoid, and sterno-thyroid muscles above, and the abdominal muscles below, which are quite sufficient to cause a fracture of a spongy bone like the sternum. It is in this way that this bone has been broken in parturition, as in the two cases related by Chaussier,§ to which may be added those of Malgaigne and Packard, and one by Borland.|| Faget, of Mexico,¶ mentions an instance of this accident, caused by muscular action, in the person of a "showman," who, while attempting to lift some heavy weights in his teeth while his body was forcibly bent backwards, broke the sternum. Gurlt also supplies a case of a similar kind. Even a forcible contraction of the diaphragm has been known to produce a fracture of the sternum.** The patient was the victim of scirrhus of the stomach, which provoked frequent and violent vomiting: the fracture was at the upper third of the sternum, where the bone was said to be sound in structure. When the fracture takes place in forcible flexion of the body, it seems probable that the lower end of the sternum is fixed by the diaphragm, while the upper extremity is driven downward and forward by the force.

The seat of fracture may be in the manubrium, at the junction of the latter with the body of the bone (Fig. 652), in the body, or at the point of union between the xiphoid appendix and the body. When in the first situation, it has been regarded as merely an example of diastasis; but if the ossific union had been established before the fracture occurred, it would be obviously improper to regard the case as one of diastasis. When the body of the sternum is broken, the lesion occupies generally one of the lines which indicate the former separation of the bone into distinct pieces.

Fig. 652.



Fracture at the junction of the manubrium with the body of the bone.—Malgaigne.

Professor Hamilton records the case of a man, twenty-eight years old, who fell upon a candlestick, breaking the xiphoid appendix from the body and driving it directly backward towards the spine. The patient suffered from frequent attacks of vomiting, but recovered with the fracture unreduced.

The manubrium is rarely broken. Of 7 cases of this fracture admitted into the Pennsylvania Hospital, 1 was in the manubrium, 2 were in the body, and 4 in the gladiolus. Fractures of the sternum are sometimes comminuted, but rarely compound.

The direction of the fracture is approximately transverse; in a few instances it is longitudinal.

The displacement is determined by the direction in which the fracturing force acts. When the injury is produced by extreme extension of the body, the lower fragment is displaced forward, and may

* Surgery, vol. i. p. 964.
† Mémoire sur la Fracture du Sternum.
‡ Bulletin de Thérapie, t. vi.
§ Revue Médicale, 1827, t. iv. p. 260.
|| Boston Medical and Surgical Journal, April 20, 1875, Hamilton.
¶ Roger Dulos, Maladies du Sternum, Thèse Inaugurale, Paris, 1835, Malgaigne.
** Gazette des Hôpitaux, March 20, 1830.

overlap the upper one slightly, whilst in those produced by flexion the upper fragment takes a position in front of the lower one, being driven in the direction of the incline, the lower part of the bone being fixed by the bent position. Unless some unusual influences such as the above are operating, there may be no displacement whatever, the parts being held together by the aponeurotic expansion of the pectoral muscles in front and the strong membranous expansion behind the bone.

Symptoms.—The patient is often able to recognize the cracking of the bone at the time of the injury. Severe pain is experienced in the parts, which is aggravated by any cause producing disturbance of the fragments, such as full breathing, pressure, or coughing. Crepitus may be heard or felt by placing the ear or the hand over the seat of fracture and urging the patient to breathe as strongly as possible. Discoloration and swelling soon follow the accident. The sternum is one of the bones of the skeleton which exhibits a singular variety of form. Some of these malformations are congenital, others are induced by mechanical causes, and are often so peculiar that they might readily be mistaken for the deformity attending a fracture.

Complications.—These are such as grow out of the relation which exists between the sternum and the organs of the chest. A fragment may be driven inward and wound the lung, producing emphysema, bloody expectoration, and embarrassed breathing. Dupuytren* and others† record such cases. Even the heart may be wounded. A specimen illustrative of this accident is in the museum of University College, London,‡ the right ventricle having been torn by a fragment of the fractured sternum. Dupuytren witnessed a similar case. Duverney, as quoted by Malgaigne, records two cases of the same kind, and Sanson§ mentions one. Blood may accumulate in the anterior mediastinum; an abscess may form in the same region and find its way to the lower end of the sternum, pointing in the epigastrium; necrosis of the bone may follow; and lastly, there may be a fracture of the spine associated with that of the sternum. In the report from the Surgeon-General's Office, Washington, six cases of gunshot fracture of the sternum are recorded.‖ Two of these died, and four survived, but three of the four became pensioners in consequence of disability from dyspnœa, cough, etc. In the case of entire recovery, the destruction of the bone was so great that the arch of the aorta was exposed and its pulsations were seen through the external wound. A somewhat similar case was that of the French general Champeux, who received a gunshot wound of the sternum at the battle of Marengo¶ which exposed the pulsations of the heart after the removal of the fragments.

Prognosis.—If a simple fracture exists without any of the complications noticed, a good recovery may be expected; but where there is evidence of intra-thoracic damage, the prognosis should be cautious and reserved.

Treatment.—If there is evidence of overlapping, or other displacement, an effort must be made to correct it, and with this view the patient should be made to take a full inspiration, or, failing in this, the body may be extended over a firm pillow or cushion, the arms at the same time being drawn well up, and the thorax below pressed strongly down. If these efforts are not sufficient to correct the displacement, it is better to allow it to remain undisturbed. Over the sternum a compress may be placed, and the entire thorax surrounded by a broad piece of canton flannel, firmly and neatly pinned, and kept from slipping down by two strips passing over the shoulders and made fast, front and back, after the manner of the double T bandage. (Fig. 651.) An excellent dressing may be made by adhesive strips applied across the sternum, extending on each side almost to the angles of the ribs,

* Dupuytren, Leçons Orales, vol. ii. p. 215.
† Flajani, Collezione d'Osservat., t. ii. p. 214.
‡ Cooper's Surgical Dictionary, vol. i. p. 711.
§ French Medical and Surgical Dictionary, article on Fractures.
‖ Surgical History of the War of the Rebellion, Part I., surg. vol., p. 486.
¶ Leveillé, p. 214.

and covering in the bone nearly its entire length. Whatever position is most comfortable to the patient should be allowed, whether lying, sitting, or semi-recumbent; and in case there is much difficulty of breathing, accompanied with oppression, it may be necessary to avoid all dressing to the chest. Operations for the elevation of depressed fractures of the sternum may be regarded as of doubtful propriety, though such have been proposed by Verduc, Petit, Delpech, and Nélaton. No cases, however, are given by these authorities in which, by incisions, trephine and elevator, or hook, they have corrected such depressions. The case given by La Martinière, in which the elevator was used, proved unsuccessful. The difficulty of correcting the displacement is not greater than that of preventing its recurrence.

The internal complications must be met as they arise. Should the pleura or the lung be injured or become inflamed, accompanied by dyspnœa and cough, the abstraction of blood and the administration of opiates will be demanded. The escape of blood into the mediastinum must be left to the action of the absorbents.

The presence of an abscess in the same locality is difficult to diagnose, and, although I opened the sternum in one instance in search of a purulent collection, and with a satisfactory result, the weight of professional authority is decidedly adverse to such a procedure. It is better, no doubt, in most cases of this nature, to wait until the abscess points, which pointing, for anatomical reasons, will probably be at the margin of the sternum, or through an intercostal space. When this occurs, it may be opened without any injury to the pleura.

When necrosis follows, we must be content with picking away the dead fragments as they separate. Unfortunately, the tendency is to caries rather than to necrosis, and without any disposition to limitation. The operation practiced by Gibson* on the sternum, with a view to arrest the progress of the osteitis, namely, excising the diseased parts, did not accomplish any good; the progress of the inflammatory condition was not materially arrested.

FRACTURE OF THE BONES OF THE UPPER EXTREMITY.

Fractures of the Clavicle.

The position of the clavicle in the mechanism of the shoulder is one which peculiarly exposes this bone to fracture. Its situation is very superficial, and its connections to the sternum and the acromion process of the scapula are such that it necessarily receives a part of all forces which are transmitted through the arm or the shoulder.

The S-shaped form of the bone is that best adapted to resist the violence to which it is so constantly exposed. Malgaigne, in a collection of 2358 fractures, found the clavicle broken 228 times. Of the 2705 fractures of the upper extremity treated in the Middlesex Hospital during a period of sixteen years, 772 involved this bone.† In the Pennsylvania Hospital, of the 8662 fractures treated between the years 1830 and 1874, 696 belonged to the clavicle. As compared with the other bones of the skeleton, its fractures stand fifth in order of frequency.

The accident is met with at all periods of life. I have seen it in children at the breast. Quite a number of intra-uterine fractures of this bone have been recorded: one by Dr. Atkinson, of Philadelphia,‡ seven by Gurlt,§ and one by Professor Gross.‖ From twenty to thirty seems to be the period in which this injury most frequently occurs. Males suffer oftener than females;

* Surgery, vol. i. p. 269.
† Holmes's System of Surgery, vol. ii. p. 764.
‡ Boston Medical and Surgical Journal, July 26, 1860.
§ Handbuch d. Lehre von d. Knockenbrüchen, Th. 2, L. 2, p. 595.
‖ Surgery, vol. i. p. 952.

although Malgaigne asserts that after sixty-five years the preponderance is in favor of females.

In 366 cases at the Pennsylvania Hospital in which the side was recorded, the fracture occurred 203 times on the left side and 163 times on the right.

Fractures of the clavicle are produced both by direct and by indirect forces. Among forces acting directly may be enumerated blows from bludgeons, spanners, the wheels of wagons, and falling pieces of timber which strike the upper part of the chest. When broken by direct force, the bone generally yields near its outer third, a part where it is most slender and least able to encounter resistance. The direction of the separation in such cases will be more or less transverse. It is in this way that compound and comminuted fractures of this bone are produced. The indirect causes are all those forms of violence which are received by the hand, the elbow, or the shoulder, and are transmitted to the clavicle through the arm. In these cases the bone may give way at any point between its sternal and acromial ends.

Sometimes these fractures are the result of muscular action. Instances of this kind are mentioned by Malgaigne,* Hamilton,† and Gurlt, the latter having collected no less than twenty examples of the accident. All of these fractures appear to have taken place near the middle of the bone, and, as might be expected, on the right side, most persons being right-handed.‡

Fractures produced by indirect force are generally more oblique than those caused by direct violence, and run commonly from before backward, involving in frequency, first, the middle of the bone (Fig. 653); second, the acromial end (Fig. 654) external to the trapezoid portion of the coraco-

FIG. 653.

Oblique fracture through the middle of the clavicle.—Malgaigne.

FIG. 654.

Fracture at the acromial end of the clavicle.—Malgaigne.

clavicular ligament; and last, though very infrequently indeed, the sternal end.

The relative frequency given by Hamilton in 105 fractures was 88 through the middle third,—and nearly always in the outer part of this portion,—13 through the acromial third, and 4 through the sternal third. Of these last, two were said to be situated within one inch of the sternal end. R. W. Smith asserts that there are no dissections verifying such a fracture,—that is, one inside the rhomboid ligament. Malgaigne, however, refers to two specimens in the Dupuytren Museum. Lonsdale§ mentions the case of a child in which the break was within these limits, or half an inch from the sternum, but believes it to be a separation of the epiphysis. Flower very properly thinks this could not be, as the epiphysis at the sternal end is a mere disc hardly exceeding one-eighth of an inch in thickness. Blandin|| and Malgaigne each describe a case which came under their care, in which there is reason to believe that the fracture was in this region.

Fractures of the clavicle are sometimes bilateral. That the accident is quite uncommon will appear from the fact that in 2358 cases at the Hôtel-Dieu only 1 case of this kind occurred.¶ Hamilton records two such cases,** and states that the New York Hospital reported 4 fractures of both clavicles in 158 cases received into the institution. Mr. Erichsen met with one case in the University Hospital, and Bryant†† has seen such cases more than once.

* Treatise on Fractures, Packard's trans., p. 376.
† Fractures and Luxations, p. 179.
‡ See Table of Fractures.
§ Practical Treatise on Fractures, 1838, p. 208.
|| Gazette des Hôpitaux, April 22, 1845.
¶ Treatise on Fractures, Packard's trans., p. 398.
** Fractures and Luxations, p. 184.
†† Surgery, p. 842.

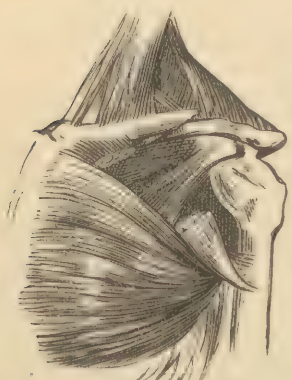
No instance of the kind is recorded among the 696 fractures of this bone treated in the Pennsylvania Hospital.

Incomplete separation of the bone is by no means uncommon. Especially is this true in children and in young persons, both of whom furnish many cases of broken clavicle.

Symptoms.—These are loss of power, pain on pressure, and deformity in the line of the bone, which may be easily discovered by running the fingers along its surface. The patient is not able, save in exceptional cases, to carry the hand to the head or to the opposite shoulder. Instinctively the hand of the sound arm is placed under the elbow of the injured one, and, while the body is slightly bent forward, the head is inclined towards the damaged side. The affected shoulder is lower than its fellow. Crepitus may generally be felt by grasping the injured arm and carrying it upward, outward, and backward, while the fingers are placed over the seat of the suspected fracture.

Displacement.—When the fracture is complete and passes through the body of the bone, or near to the outer third, the displacement will be greatest, and is very uniform in its character. As this displacement is largely due to the movements of the shoulder, the acromial fragment will be most affected. The sternal fragment will be drawn somewhat up by the clavicular fibres of the sterno-cleido-mastoid muscle. This, however, will in most cases be inconsiderable, as both the costo-clavicular or rhomboid ligament and the subclavian muscle and aponeurosis oppose such a movement. The acromial fragment is, first, carried down by the conjoined action of the weight of the shoulder, the serratus magnus, the latissimus dorsi, and the pectoralis major and minor muscles, thus falling below the level of the sternal fragment; secondly, it is drawn inward and forward by the sternal portion of the pectoralis major, plus the weight of the shoulder; thus it overlaps the sternal fragment; and, thirdly, it is carried under and even behind the sternal fragment, by the same agencies, with the assistance of the rhomboideus major and minor muscles. These last muscles, acting on the vertebral border of the scapula, serve to impress on this bone a movement of rotation, which changes the acromial fragment from an anterior to an under or posterior position in relation with the sternal fragment (Fig. 655): so that the order of changes to which the acromial end of the clavicle is subjected is downward, forward, inward, and finally backward. The overlapping may amount to one inch. In my possession are two broken clavicles in which it is one inch and a half. In children the overlapping is rarely ever, even relatively, as great as in adults, and indeed this is true of the entire series of displacements. In a few instances the acromial has been known to override the sternal fragment, the latter being depressed. Desault, Malgaigne, Stephen Smith, and others have observed such cases. When a relation of this kind exists between the two ends of the bone, it is probably due to force directly applied, impelling the sternal fragment down, and thus allowing the acromial fragment to slip over it as the shoulder falls inward.

Fig. 655.



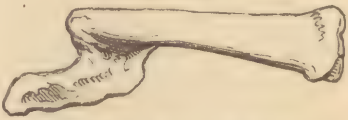
Position of fragments in oblique fracture at the middle of the clavicle.

When the acromial end of the bone is broken, the displacement is not great; though even in this position the degree of disarrangement is influenced by the position of the fracture. If it takes place between the two portions of the coraco-clavicular ligament, it will be very trifling, as the fasciculi of the latter, with the periosteum, serve to resist a separation of the fragments; but if the bone is broken internal to this ligament, the displacement will be quite marked. The inner extremity of the acromial piece will

be pulled upward by the trapezius muscle, while the weight of the shoulder and the influence exerted by the muscles of the chest will carry the acromial end downward and inward, placing the entire fragment at a considerable angle with its fellow. (Fig. 656.)

When the fracture is within the limits of the coraco-clavicular ligament, its existence must be determined by the pain experienced on pressure, and by the movement and, perhaps, the crepitus produced by grasping the fragments with the fingers and forcing them in opposite directions. When external to the ligament, there will be less obscurity, and by fixing the sternal fragment with the fingers and moving the shoulder backward and forward, we can secure the decisive sensation of crepitation.

Fig. 656.



Fracture of clavicle internal to the coraco-clavicular ligament.—Malgaigne.

When the fracture is situated at the sternal end of the bone and within the limits of the costo-clavicular ligament,—an exceedingly rare accident,—there will be little displacement, unless the fracturing force is applied to the outer side of the shoulder, driving the acromial fragment forward and downward; but when external to the ligament, the acromial fragment will be driven downward by the action of the clavicular portion of the pectoralis major, and carried forward by the weight of the shoulder and by the pectoralis major and minor muscles.

To detect this form of fracture, the fingers must act directly on the broken ends, with a view to discover movement and crepitus. When displacement is present, of course the diagnosis is comparatively easy.

In transverse fractures of the clavicle (certainly not very common), wherever situated, there is frequently little or no displacement. Some writers have practically denied the existence of such fractures; but there can be no doubt of their occurrence. Hamilton* has seen four such cases, Stephen Smith two, Desault† several, and I have seen one, in the person of a child three years old. In the "Surgical History of the War of the Rebellion"‡ there is an excellent example of a transverse fracture. The entanglement of the serrations doubtless prevents the displacement.

Compound Fractures of the clavicle, except as a result of gunshot wounds, are uncommon, and when they do occur from this cause are often attended with serious injury to the organs of the chest. A simple fracture, if very oblique and much displaced, may produce ulceration of the integuments and become a compound one. The union under such circumstances is delayed.

Comminuted Fractures, when not from gunshot injury, are the result usually of direct force, and are followed by considerable deformity. The fragments may be variously disposed. Malgaigne§ had a case in which the middle fragment assumed a vertical position between the other two, and Hamilton|| met with a similar one. In case of comminution, associated with an external wound and followed by necrosis of a fragment, the dead bone must be discharged before consolidation of the fracture takes place. The case treated by Lente and related by Hamilton¶ is an example of this statement.

Complications.—The position of the brachial plexus of nerves and of the subclavian vessels is such that these structures are exposed to injury by depressed portions of the clavicle. If the nerves are compressed, partial or complete paralysis of the arm may follow. The death of Sir Robert Peel was in part attributed to the existence of a large pulsating tumor under a comminuted fracture of the clavicle, supposed to have been due to a wound of the subclavian vein.** In Holmes's Surgery a specimen is described which is at present in the museum of St. George's Hospital, and in which a fragment

* Fractures and Luxations, p. 181.

† Fractures, p. 15.

‡ Part First, p. 482.

§ Fractures, p. 377.

|| Fractures and Luxations, p. 183.

¶ Fractures and Luxations, p. 184.

** London Lancet, July 6, 1850.

of the clavicle has passed through the internal jugular vein. Erichsen* had a case which he supposed to be one of injury to the subclavian vein from the same cause, in consequence of the extensive extravasation of blood which was present; and more recently, the same surgeon met with another instance of damage to the subclavian vessels, which was followed by gangrene of the arm.†

A patient applied to Professor Gibson to be relieved of paralysis and atrophy of the arm following a comminuted fracture of the clavicle. The bone was much depressed below the level of the neck.

Dr. H. W. Boone,‡ Assistant Surgeon U.S.A., published the history of a patient who received a comminuted fracture of the clavicle. A fragment of the bone compressed the subclavian vein and the brachial plexus of nerves. The arm was cold, the veins were much swollen below, and the parts quite numb. These symptoms gradually disappeared, and the individual recovered.

Prognosis.—Fractures of the clavicle unite much more rapidly than do those of most other bones of the skeleton. I am confident that I have seen a good degree of union take place in from twelve to fourteen days. Union, however, without deformity is a rare occurrence,—so rare, indeed, that when the fracture is complete and involves the body of the bone with the line of separation running obliquely, I can recall no instance of a perfect cure. There is almost always some overlapping or some upward angular projection which can be seen or felt. Hamilton,§ in seventy-two complete fractures, found shortening in all except sixteen, and of twenty-seven complete oblique fractures at the acromial end of the middle third, all had shortening save one. The collection of clavicles in the museum of the University of Pennsylvania, and that in the College of Physicians of Philadelphia, furnish many examples of fracture, but, when the injury is located near the middle, or internal to the coraco-clavicular ligament, none in which some deformity does not exist. Fortunately, neither shortening nor angular deviation materially affects the strength or the usefulness of the limb.

Examples of *non-union* of the fragments of this bone are by no means common. This condition is most likely to follow cases in which both clavicles are simultaneously broken. Malgaigne, in six cases of this accident, had three ununited fractures. Even when osseous union does not occur, the ends of the bone being united only by dense fibrous tissue, the patient will be able to execute the ordinary movements of the arm with a good degree of precision and power. Hamilton‖ relates the case of a workman who, with a limb defective from this cause, was yet able to raise, within a few ounces, as great weights as with the sound arm. Malgaigne gives, among others, the case recorded by Gerdy, of an aged cuirassier who, with a broken clavicle united by a ligamentous cord, could execute his duties without any inconvenience. Even where both clavicles have been broken and have remained ununited, the disability is not very great.

Treatment.—If any doubt existed as to the difficulty encountered in the management of fractures of the clavicle, it would be quickly dissipated by an inspection of the formidable array of contrivances which have been devised from time to time to meet the indications required. The anatomist will see at a glance that the source of all trouble and perplexity in the treatment of this accident is the mobility of the scapula, and until we can give a complete fixation to this bone we shall never be able to effect what are called perfect cures.

What is the problem to be solved? It is to carry the shoulder *upward*, *outward*, and *backward*, and to keep it there, thus restoring the acromial fragment—the one principally displaced—to its proper position. No one has as yet satisfactorily accomplished these ends. There is a movement of the scapula by which it describes a considerable arc of a circle upon

* Surgery, vol. i. p. 348.

† British Medical Journal, June 7, 1873.

‡ Medical Record, November 15, 1873.

§ Fractures and Luxations, p. 185.

‖ Fractures and Luxations, p. 187.

the side of the thorax. When the arm of a person is carried strongly forward and backward, the inferior angle of this bone can be seen advancing and receding beneath the integument. Herein lies the whole difficulty; and not until this movement can be controlled shall we be able to command the best results. No dressing which does not keep the inferior angle of the scapula forward can fulfill the desired object, however well other indications may be met.

A historical review of the various methods advocated by different surgeons for the reduction and retention of this fracture would only present us with a vast array of conflicting and contradictory procedures, which would scarcely repay for the time expended in their narration.

All forms of treatment may be arranged under two general heads,—one proposing to treat the patient in the erect and the other in the recumbent posture; and they may be described in this order.

Erect Position.—The three indications to be fulfilled in the reduction of a broken clavicle are to carry the shoulder upward, outward, and backward. All these movements are designed to affect the acromial fragment. The first brings it to the level of the sternal piece; the second removes the overlapping; and the third restores the line of the bone. To effect these important purposes permanently, the surgeon will be compelled to vary his appliances. No single dressing will answer for every case. There are three plans which I find, in a majority of instances, give me the most satisfactory results, namely, the dressing of Velpeau, that of Fox, and that by adhesive plaster.

As a temporary or provisional dressing,—one which will serve to fix the arm while a patient is being removed from the place of accident to his home or to a hospital,—the handkerchiefs of Mayor answer an excellent purpose. Fold one handkerchief into a triangular form, place the body under the forearm, and carry one of the ends over the back and the other over the front of the chest to the sound shoulder, over which they should be tied. Fold a second handkerchief into a cravat, and tie the arm to the body. (Fig. 657.)

Fig. 657.

Mayor's handkerchief dressing for fracture of the clavicle.

Fig. 658.

Velpeau's dressing for fracture of the clavicle.

Dressing by a Velpeau roller.—By this method the arm of the injured side must be flexed and brought across the front of the chest, so that the hand will rest on the shoulder of the sound side and the elbow point in the same direction, after which the roller should be applied according to the manner of Velpeau. (Fig. 658.)

This dressing will be found, in a large number of cases, to answer a most admirable purpose. The flexed arm, being carried across the chest, draws the lower angle of the scapula forward, by making tense the teres major

muscle, and necessarily causes the acromial fragment of the clavicle to rise upward and backward; secondly, the arm, reposing on the most prominent convexity of the chest, possesses in the latter a fulcrum which serves to keep the scapula out; and lastly, when in this position the elbow is forced upward and outward, by the diagonal turns of the roller these last movements are increased and the axillary pad is rendered unnecessary, while the circular turns of the bandage make secure all the advantages gained by the position of the limb.

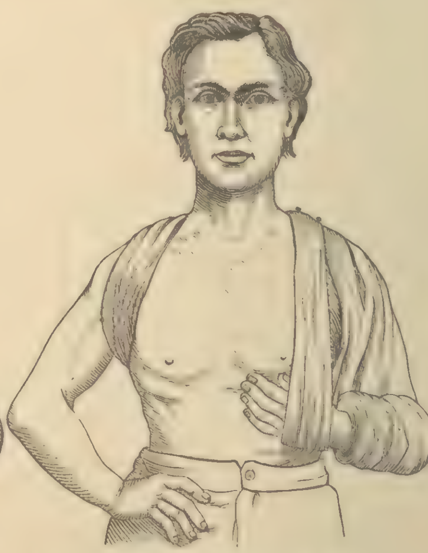
The records of surgery exhibit a singular diversity of opinion on the subject of the best position of the upper extremity in fractures of the clavicle. Paré had the arm carried back with the hand resting on the hip. Grout brought the flexed arm still farther back, so as to bring it in contact with the loin. Guillou placed both the arm and the forearm across the back before raising the elbow. Chelius moved the elbow backward on the body.

Moore's.—Professor E. M. Moore, of Rochester, advocates carrying the elbow back, in order to make tense the clavicular fibres of the great pectoral muscle, thus neutralizing the action of the sterno-cleido-mastoid muscle on the sternal fragment, and, by drawing the scapula towards the spine, raising the acromial fragment outward and upward. The mode of applying the dressing which is to accomplish these ends is as follows. Flex the arm across the chest, the elbow being brought well to the side of the body; take a strip of strong muslin seven or eight inches wide and two and a half yards long, place the centre of the strip on the point of the elbow, and conduct the ends upward to the axilla, where they are to be crossed, the anterior strip being brought behind and the posterior one in front of the shoulder. The bandage is completed by bringing the anterior piece down over the back of the shoulder of the injured side and the posterior piece up over the sound shoulder, and, after crossing the two in the axilla of the uninjured side, fastening them together. The forearm is next flexed and suspended in a sling. This dressing is designated by its author the figure-of-eight of the elbow, and is represented in Figs. 659 and 660.

FIG. 659.

Moore's figure-of-eight of the elbow for fracture of the clavicle, posterior view.

FIG. 660.



Moore's figure-of-eight of the elbow, anterior view.

Sayre's.—Dr. Sayre, of New York, proposes to accomplish a similar result by maintaining the arm in very much the same position by two strips of ad-

hesive plaster, the first three and a half inches wide, and sufficiently long to surround the arm and afterwards the body; this strip is made to encircle the arm over the insertion of the deltoid muscle, in the form of a loop, larger than the arm, and must be stitched to make it secure. The arm, being carried strongly backward and downward, so as to make tense the clavicular portion of the pectoralis major, is next secured by carrying the strip entirely about the body and fastening it on the back to itself. The other strip is placed over the sound shoulder, carried obliquely across the back, and brought beneath the elbow of the damaged side, a slit being made in the plaster to receive the olecranon projection. It is then conducted upward in front of the chest to the place of beginning. (Figs. 661 and 662.)

FIG. 661.

Sayre's dressing for fractured clavicle, posterior view.

FIG. 662.

Sayre's dressing for fractured clavicle, anterior view.

Professor Gross for many years has used adhesive plaster in the treatment of this fracture, but, in applying it, very properly keeps the arm in a line with the body. Professor Hamilton believes that, like other plans, it does not prevent, at least in many cases, the overlapping of the fragments. In children, I have found that the adhesive plaster sometimes irritates the skin to a degree which makes it very uncomfortable. When it does so, it should be placed over a roller previously applied.

We have then three positions of the arm, advocated by different writers, viz., forward, backward, and vertical, all represented as accomplishing the same end, and excellent results claimed for each. I can understand how three roads may converge to the same town, but I cannot conceive how three travelers who move in different directions can reach the same destination.

The introduction of a wedge-shaped axillary pad into the dressing for fractured clavicle is deemed essential by many very excellent surgeons, among them Fergusson, Syme, Liston, and Erichsen, and, in this country, Dorsey, Gibson, Norris, Peace, Fox, Hamilton, Smith, Levis, and others. The object of this pad is to serve as a fulcrum, by which the shoulder can be carried upward and outward, and the overlapping prevented or overcome. This is not a modern appliance, but dates back to the time of Galen. It has, however, undergone material changes in form and size. It was at first a mere cushion, or thick compress, and did not assume the cuneiform shape until the time of Desault. It was as long as the humerus, five inches wide, and

three inches thick at the base. The length of this pad was reduced almost one-half by Flamant; and those who at the present time favor its use have diminished its size still more, until it may be stated to be six inches long, one inch and a half thick at the base, and three and a half or four inches wide, so as nearly to fill up the axillary space. (Fig. 663.)

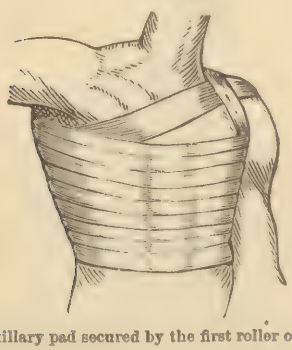
FIG. 663.

Axillary pad.

Desault's.—This pad, and three rollers, each two and a half inches wide and eight or nine yards long, constitute Desault's apparatus, which is applied as follows. The patient being seated on a stool, the arm of the injured side is raised to a right angle with the body, and the pad, with its base upward, is placed in the axilla. The initial end of one of the rollers is laid upon the pad, and a few circular turns are made about the chest to fix it, after which the roller is carried obliquely across the front of the chest, over the sound shoulder, through the corresponding axilla, across the chest, over the pad, and along the back over the sound shoulder, returning to the back through the axilla, and terminating the bandage by spiral turns about the thorax. The pad is thus made secure. (See Fig. 664.)

The arm, flexed to a right angle, is next brought to the side, by which, through the resistance of the fulcrum, or pad, the acromial fragment is carried outward. The arm should next be pushed upward and backward, with a view to bringing the two fragments to the same level and on a line with each other. To maintain this position is the object of the second roller, the initial end of which is to be placed in the axilla of the sound side and carried over the front of the chest, over the upper part of the arm of the fractured side, and round the posterior part of the body to the point of starting, repeating

FIG. 664.



The axillary pad secured by the first roller of Desault.

FIG. 665.

The second roller of Desault.

these turns until the elbow is reached. As the elbow must be drawn to the side by the roller, it is necessary that the first turns be loose, each successive one being drawn tighter as they descend. (See Fig. 665.)

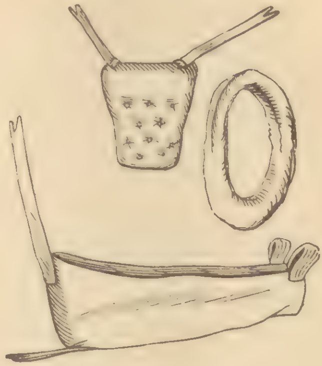
To assist in keeping the arm upward and backward, and to fulfill the two indications already named, viz., keeping the acromial fragment on the same plane and in the same line with the sternal fragment, a third roller is commenced in the sound axilla, carried obliquely across the front of the chest, over the seat of fracture (a compress being interposed), down the back of the arm, beneath the elbow, and over the front of the chest to the place of beginning. From this point the roller is continued through the axilla of the sound side, across the back to the seat of fracture, down in front of the arm to the elbow, and then across the back to the sound axilla; from which it starts anew over the fracture, repeating the turns first made, and in the same order, thus forming two triangles,—one in front and one behind the body. The

roller is terminated by making a few spirals of the arm and the chest. (See Fig. 666.)

Fig. 666.

The third roller of Desault.

Fig. 667.

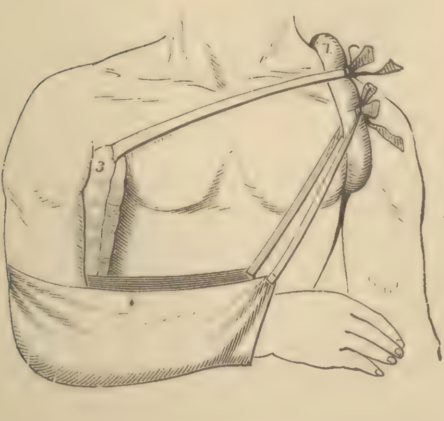


Fox's ring, sling, and pad.

This dressing, when accurately applied, is capable of effecting very satisfactory cures; but, in consequence of its complexity, and its liability to become deranged, it is fast falling into disuse. Professor Gibson, in order to prevent its displacement, was in the habit of brushing over the rollers a coating of starch.

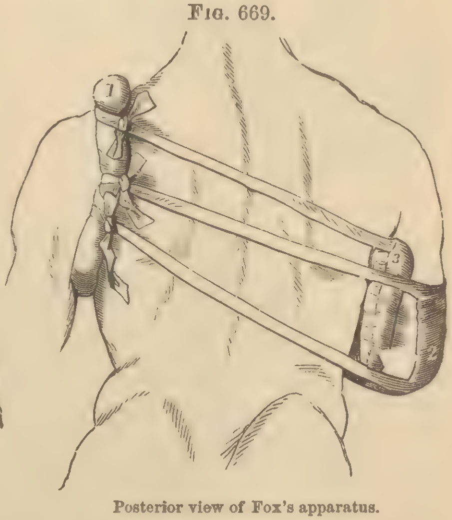
Fox's.—In 1828, Dr. George Fox introduced into the Pennsylvania Hospital a very simple apparatus, which has had a wide-spread popularity among American surgeons. It consists of a ring, a sling, and a pad. (Fig. 667.) The ring is made of muslin or chamois, well stuffed with cotton or hair, and large enough to encircle the arm at the shoulder. The sling is made of stout muslin, and should receive the elbow, extending up the arm four inches, with two broad tapes of linen webbing, one of which is attached to the upper and the other to the lower part of the elbow piece. The wedge-shaped pad must be large enough to fill up the axillary space, and may be prepared of twilled muslin, well stuffed with hair, and with wide tapes connected to the angles of its thick end.

Fig. 668.



Front view of Fox's apparatus for fractured clavicle.

Fig. 669.



Posterior view of Fox's apparatus.

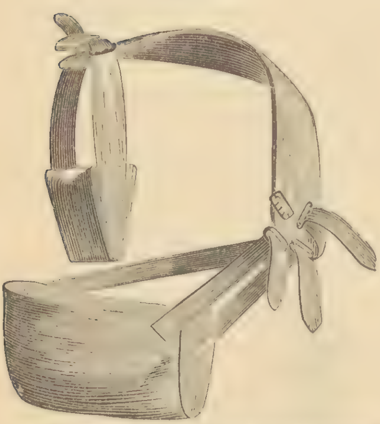
In the application of this dressing the ring is to be slipped over the arm of the uninjured side, and the pad placed in the axilla of the fractured side and

there maintained by tying the tapes into the ring. The arm is next placed in the sling, and the wrist suspended to the ring by the front tapes, after which the elbow, being carried upward and backward, must be also secured to the ring by the tapes attached to the upper and lower parts of the posterior portion of the sling. (Figs. 668, 669.) Cotton should be placed between the skin and the tapes, in order to prevent excoriation. The simplicity of this apparatus of Dr. Fox's is calculated to give it great acceptance with the profession. It has the sanction of many eminent names, has been in constant use in the Pennsylvania Hospital for over forty years, and still retains its popularity there. In the treatment of fractures located at the acromial or the sternal end of the clavicle, I know of no apparatus which yields more satisfactory results. In those involving the body of the bone, it is incapable, in common with all others, of effecting a perfect cure.

Professor Hamilton employs a dressing which operates very much as does that of Dr. Fox. It consists of an axillary pad, a sling, and a roller. The pad is placed in the axilla, the sling passed under the arm and the elbow of the affected side, and its ends tied over the shoulder of the opposite side, the arm being afterwards bound to the body by circular turns of the roller.

Levis's.—Dr. Levis, in 1856, devised a modification of the Fox apparatus, by which the ring is omitted, and a strap substituted for it, which passes across the upper part of the back and shoulders. It is very quickly applied. Figs. 670, 671, and 672 will sufficiently explain the application of the dressing.

Fig. 670.



Pad, sling, and strap of Levis's clavicle apparatus.

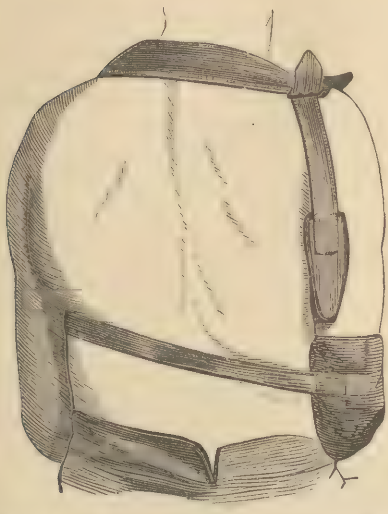
Fig. 671.

Front view of Levis's apparatus adjusted to a patient.

In the use of any appliance in which the axillary pad is employed, it should not be forgotten that undue pressure may be made upon the axillary nerves and blood-vessels. Paralysis has followed its use. Hamilton has cited a case of this kind, and also Parker of New York. When the arm is on a line with the side of the body, the nerves are least exposed to pressure. When the fracture is near the acromial end of the bone, the case may be satisfactorily treated by the four-tailed sling, which can be quickly prepared by taking a piece of muslin, seven inches wide and two yards long, and slitting it down from each end, leaving the centre intact for twelve to fourteen inches, in which a small opening should be cut. In its application the arm must be flexed and the hand laid upon the opposite clavicle. The opening in the centre of the sling receives the point of the elbow; the arm is next to be pushed well upward and backward, and the lower tails of the sling brought up, the anterior one beneath the arm, over the breast and

the opposite shoulder, the posterior one across the back, and the two secured together. The upper tails are next carried round the arm and body, and tied

Fig. 672.



Posterior view of Levis's apparatus adjusted to a patient.

Fig. 673.

Posterior eight for fractured clavicle.

together on the opposite side of the trunk. Dugas employs a triangular sling of muslin, having a strip of roller, three yards in length, sewed to each angle. The sling is placed under the arm, extending from the elbow to the wrist, and the strips are fastened over the shoulder of the sound side and around the body. The apparatus forms a secure dressing.

Figure-of-eight.—Thus far we have been speaking of such appliances as act chiefly upon the elbow; but there are others which are intended to operate on both the elbow and the shoulder, in order to carry out the indication of moving the latter backward. The figure-of-eight bandage is so designed. (See Fig. 673.) In its application a pad is placed in the axilla of the injured side, and a roller is passed alternately about the shoulders so as to draw the scapulæ towards each other, after which the flexed arms are pinioned, by a second roller, to the front and sides of the chest. This dressing had at one time a number of advocates, among both the French and the English. Another of the same class is the apparatus of Brasdor, consisting of shoulder-straps of stuffed chamois skin, fastened to back-pieces of cloth or leather, which could be drawn together either by lacing or by buckles. After the application of the apparatus, the arm was to be placed in a sling.

Treatment in the Recumbent Position.—This method was sanctioned by Hippocrates, Celsus, La Notte, Flajani, Dupuytren, Lizars, Dorsey, Post, and others, and came into use in consequence of the unsatisfactory results obtained by the plans which were commonly employed. Dr. Edward Hartshorne* published an exhaustive paper on the advantages of this position in the treatment of fractured clavicle. The patient is to be placed upon a hard, unyielding mattress, with the arm and forearm of the injured side flexed and placed across the chest, the hand touching the opposite shoulder. In this position the inferior angles of the scapula move forward, and the superior or glenoid angles backward, the weight of the body upon the lower angles keeping them permanently in this position. The head must be placed on a low pillow, with the chin slightly depressed, so as to flex the sterno-cleido-mastoid muscles and thus allow the sternal fragment to descend. We have

* Pennsylvania Hospital Reports, 1869.

in the supine position all the conditions necessary for a proper reduction of the fracture; and it is interesting to see how instantaneously all deformity disappears the moment such a position is assumed. When the patient is docile and obedient, willing to co-operate with the surgeon to the fullest extent, and in hospitals where a careful and constant surveillance can be exercised over the inmates, this plan may be adopted for a short time, or until a certain amount of reparative material has formed about the fracture and the tendency to displacement has in some measure diminished, when some form of a walking apparatus may be substituted. Beyond this the recumbent position is scarcely practicable. It is impossible, as a rule, in a fracture like that of the clavicle, and involving so little disability, to compel a patient to remain fixedly in one position; and even where there is a willingness to do so, there are unconscious movements made in sleep which cannot well be controlled.

With these difficulties to be overcome, together with the fact that the deformity attending other methods of treatment, in which a larger liberty is allowed, detracts very little from either the strength or the usefulness of the limb, it is not probable that the recumbent position will ever become very popular or general.

In summing up this whole subject, it may be said that we have, at best, the choice of imperfect appliances for the treatment of fractured clavicle, and that no single apparatus can be used in every case to the exclusion of all others. There are three appliances, however, which, with few exceptions, will enable the surgeon to accomplish the most satisfactory results, namely, the Velpeau bandage, the Fox apparatus, and adhesive plaster. In fracture of both clavicles, the posterior eight bandage or the Brasdor apparatus will form the best dressing.

Fractures of the Scapula.

Fractures of the scapula are not by any means common: the richest cabinets furnish only a few specimens. Malgaigne states that of the 2358 fractures admitted into the Hôtel-Dieu, only 4 were in this bone. Lonsdale, according to the same author, found 18 among the 1901 fractures treated at the Middlesex Hospital. Hamilton has seen 8 cases, and I have met with the injury four times. The facts that the scapula is covered with large muscular masses of flesh, and that it moves freely over the surface of the chest, sufficiently explain the infrequency of the fracture. Of the 8667 fractures treated in the Pennsylvania Hospital during a period of forty-four years, 82, or less than 1 per cent., were fractures of the scapula. The following table, comprising 54 of these cases, exhibits some interesting points in connection with this injury:

Age.	Position of the Fracture.							Kind of Fracture.					Side.			Sex.	
	Body.	Acromion.	Spine.	Inferior angle.	Neck.	Glenoid cavity.	Not recorded.	Simple.	Compound.	Compound comminuted.	Simple comminuted.	Unrecorded.	Right.	Left.	Unrecorded.	Male.	Female.
Under 10...... 2 10 to 20...... 4 20 " 30......14 30 " 40......10 40 " 50......15 50 " 60...... 5 60 " 70...... 3 70 " 80...... 1	9	12	10	4	5	1	13	49	2	1	2	...	19	20	15	48	6

Any portion of the bone may be fractured, as the body, the angles, the processes, the neck, or the spine. The injury is usually the result of violence directly applied; but I have seen the accident follow a fall upon the arm, the force being transmitted to the scapula. South thinks that these fractures

are usually produced in this way. This, however, does not accord with the opinions of other surgeons. A case is reported by Dr. Heylen of a fracture of the scapula from muscular action alone. Malgaigne, however, doubts the verity of the diagnosis.

Fractures of the scapula are either *complete* or *incomplete*. They may be simple, compound, comminuted, or stellated. Notwithstanding the muscular case in which the bone lies, the displacement in most instances of the injury is well marked.

Fractures of the Body and the Angles of the Scapula.—A specimen of fracture involving the posterior angle of the scapula is in the Mütter collection of the College of Physicians of Philadelphia. The line of fracture commences on the upper border of the scapula and passes through the spine, terminating some distance below in the fossa infra-spinata. (Fig. 674.) The existence of the fracture has been discredited by some surgeons. This specimen, however, is quite familiar to Philadelphia surgeons. In the Middlesex Hospital museum there is a specimen, figured in Holmes's Surgery, in which the fracture passes through the upper part of the glenoid cavity, and, running in a zigzag direction across the fossa supra-spinata for a short distance, divides into several radiating fissures.

Fig. 674.

Fracture of the posterior angle of the scapula. Mütter collection.—Hamilton.

Fig. 675.

Transverse fracture through the body, or fossa infra-spinata.

Malgaigne alleges that fractures of the body of the bone are most commonly situated above the spine. Hamilton, on the contrary, places them below the spine (Fig. 675); and this accords with my own observation. In three specimens of this injury belonging to the museum of the University of Pennsylvania, such is the situation of the fractures.

Symptoms.—When the spine is involved, on account of its superficial position, any break in its continuity may be determined by passing the fingers over the surface of the bone, or by seizing it between the thumb and finger of each hand and pressing in opposite directions. If the body below the spine is broken, mobility and crepitation may be ascertained by grasping the inferior angle with one hand and moving it back and forth, while with the other the shoulder is fixed. Some deformity may be expected where the separation is complete, and also pain, especially when the arm is carried for-

ward, as the teres major muscle, by such a movement, tends to drag the broken fragments in the same direction. The shoulder is always more or less disabled. Malgaigne directs carrying the forearm behind the back, and raising the hand as much as possible, a position which makes the posterior border of the scapula very prominent and reveals any defect in its edge. When the fracture is above the spine of the scapula, the posterior angle will be the most accessible point to seize in order to determine the existence of crepitus and undue motion. When the lower angle is broken, there can be no difficulty in forming a diagnosis, as we have this portion of the bone so entirely under our observation.

Prognosis.—The gravity of this fracture depends upon the amount of damage done to the soft parts, the degree of comminution, and the shock which may have been communicated to the organs of the chest. When the injury is a gunshot one, there may follow abscesses, necrosis, and stiffness of the arm. It is under such conditions that resection of portions of the bone become necessary; and the operation was frequently performed during the War of the Rebellion. When, however, it is a simple fracture, union takes place generally with some overlapping. As to this overlapping, there is nothing uniform; sometimes the lower and sometimes the upper fragment is in front. The displacement is probably due to the direct influence of the force, rather than to muscular action.

Treatment.—While great differences of opinion prevail among surgeons as to the proper dressing, there is one point upon which all agree, namely, that of giving fixation to the scapula; and this involves the entire quietude of the arm. After making a proper adjustment of the fracture, a broad strip of adhesive plaster should be applied across the scapula, extending from the spine to within four inches of the sternum, taking care to press it well down along the anterior and posterior border of the bone before the portions in front of and behind the chest have been attached. Then place the arm in a Fox apparatus, and allow it to hang vertically along the side of the body, at the same time lifting the elbow by securing the straps to the ring on the opposite shoulder. To prevent the arm from being carried away from the side, a few turns of a roller around the arm and body should be applied, or the same end may be secured by surrounding the arm and chest with a broad strip of muslin, which can be fastened with pins. The vertical position of the arm is the one which gives relaxation to both the teres major and rhomboideus muscles, and conduces most to the quietude of the fragments. I am aware that sometimes we will be foiled in effecting a satisfactory adjustment by strictly conforming to anatomical indications: where this is the case, the arm should be placed in any position which will best conduce to the apposition of the fragments, whether it conflict with anatomical teaching or not.

Fractures of the Acromion.—It will be seen by reference to the table on a previous page that fractures of the acromion process are more common than those of the body of the scapula. In Lonsdale's cases they were equal. The exposed situation of this portion of the bone would seem to render it peculiarly vulnerable. That its fracture does not occur oftener is doubtless due to the mobility of the shoulder. The causes producing the fracture are such as act either from above, as when some heavy object falls upon the shoulder, or from below, as when the head of the humerus is forcibly driven upward. The tardy consolidation of the epiphyseal extremity of the acromion process with the other portion of the bone has doubtless led to many errors in diagnosis, by a separation of the diaphysis being mistaken for fracture. I have frequently noticed in the process of boiling bones for the preparation of skeletons that the cartilaginous bond was present, and the tip of the process often detached, even in bones which appeared to be those of persons well advanced in life; and I think, after a careful examination of cabinet and other specimens of supposed acromial fractures, that the statement of Fergusson, that "such accidents are rare," will be found to be correct.

The position of the fracture varies. It may be in front of or behind the acromio-clavicular junction, or (Fig. 676) it may extend into the articulation. Sir Astley Cooper describes an instance of the latter condition attended with a luxation of the clavicle; and a similar case came under my own notice.

Fig. 676.

Fracture of the acromion process.—Malgaigne.

Symptoms.—The symptoms which indicate this fracture are pain, flattening of the shoulder, deformity, great disability of the arm, unusual mobility, and crepitus. The pain is intensified by moving the arm. The rotundity of the shoulder is diminished by the weight of the upper extremity dragging the acromion fragment downward through the attachment of the deltoid muscle. A finger passed over the seat of injury will detect the irregularity, and may be pressed between the fragments, and if the break is posterior to the acromio-clavicular articulation there will follow a deformity resembling that resulting from fracture of the humeral end of the clavicle, the shoulder dropping downward, inward, and forward.

When the break extends into the acromio-clavicular joint, the end of the clavicle will rise up and form a prominence over this part of the shoulder. The head will be inclined to the injured side, and the patient will support the arm with the opposite hand. Crepitus may be felt by placing one hand over the summit of the shoulder, and with the other forcing the arm upward and rotating it quickly. Discoloration will usually be present, though, as in other fractures, it may not appear until some time after the accident.

This injury has been mistaken for luxation of the humerus. An error of this kind is inexcusable. In luxation the acromion process is salient and sharply defined; in fracture it is flattened. In luxation the elbow stands off from the body; in fracture it lies close to the side. In luxation the bone once reduced so remains; in fracture, though the deformity disappears when the head of the humerus is pushed upward, it immediately reappears when the support is withdrawn.

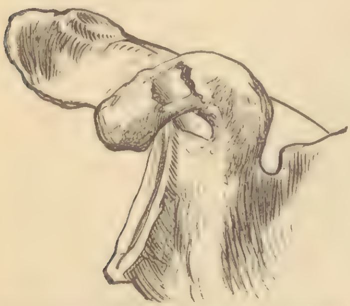
Prognosis.—In most cases the union will be ligamentous, forming a false joint. Bichat and Arrard had each a case, in which the union was osseous, as stated by Malgaigne. In these it is probable that the fragments were not entirely detached. Although the extremity of the acromion receives some blood-vessels from the acromial branch of the thoraco-acromial artery, its nutrition, when broken, must be very defective. Malgaigne says that, with a single exception,—one in the Dupuytren Museum,—the little nodules of bony matter which form about these fractures are always confined to the upper fragment. The movements of the arm, after repair has taken place, are not materially impaired, although the power to elevate the limb is very slowly regained.

Treatment.—There are two methods of treatment, one by position, and the other by retentive dressings. The first, known as that of Delpech, consists in placing the patient on his back, carrying the arm directly away from the body, and supporting it in this position upon a pillow. This posture completely relaxes the deltoid muscle, which otherwise tends to pull the detached fragment from the spine, and favors a very accurate adjustment. The only objection to this plan is that which is urged against the treatment of fractured clavicle by position, namely, inability to enforce the requisite quiet for a period sufficiently long to secure union. If the patient is not willing to endure this kind of confinement, then the Velpeau bandage, with the arm placed vertically along the side of the body, will be found best suited to the case. By this plan the head of the humerus being pushed up becomes a splint for the support of the acromion process. When the fracture passes through the acromio-clavicular articulation, or behind it, we have a condition of things not unlike that which follows a broken clavicle, and we may resort

either to this last bandage or to the Fox apparatus, consisting of the ring and the sling, either with or without the axillary pad. After a period of five weeks the dressing may be laid aside and the arm carried in a sling for two weeks longer.

Fracture of the Coracoid.—This fracture is exceedingly rare, but a sufficient number of examples are recorded to place its existence beyond a doubt. A very well marked specimen is in the possession of Prof. John Neill, of this city. (Fig. 677.) In the collection formerly belonging to Prof. Charles Bell Gibson there was a similar specimen. Hamilton records one in the possession of Dr. Mussey, and another in the museum of the Massachusetts Medical College. I attended a patient in the winter of 1876 who, after a severe injury to the shoulder, presented the signs of this fracture. One year after, I had the opportunity of verifying my diagnosis, by finding the process quite prominent, from the length of the connecting bond. As the humerus had been dislocated in this instance, I have no doubt the fracture was caused by the head of the bone. Produced as the fracture usually is by severe and direct violence, it is frequently associated with other injuries, both to the bone and to the soft parts, which render the accident one of the most serious character. Of this nature was the case related by Duverney,* in which the neck of the scapula and several ribs were found broken in a man who died after a fall, apparently in consequence of the formation of a large axillary abscess. South† mentions a coracoid fracture accompanied by an incomplete luxation of the humerus and a fracture of the olecranon process of the ulna. Another of a similar kind is given by Holmes.‡ Boyer also speaks of a fatal case, which was caused by the damage done to the soft parts.§ Erichsen|| mentions a specimen in the University College museum, in which, in addition to a fracture of the coracoid, there is a fracture extending though the glenoid cavity, with a third through the base of the acromion process of the scapula. Hamilton thinks he has met with two cases of coracoid fracture, and Flower¶ likewise with two. Bryant** has seen one case, in a girl fifteen years of age.

FIG. 677.



Fracture of the coracoid process of the scapula, with ligamentous union. From a specimen belonging to Prof. Neill.

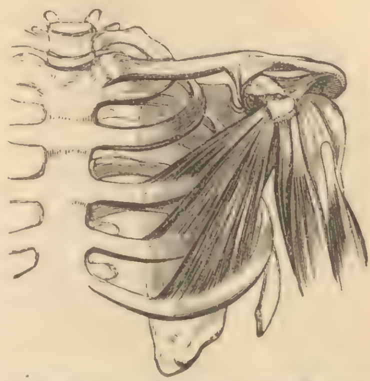
SYMPTOMS.—The signs of this injury are pain, preternatural mobility, and crepitus. If the examination is made early,—before much swelling exists,—the coracoid process can be readily touched with the finger, and if, while the digit is in contact with the bone, the humerus be moved upward and downward, the process, if detached, will be found to follow the movements of the arm, and not those of the scapula, in consequence of its connection with the coraco-brachialis and biceps muscles. The crepitus may also be felt during these manipulations.

The displacement will depend on the seat of fracture. If it is in front of the attachment of the coraco-acromial and coraco-clavicular ligaments, the tip of the process may be drawn somewhat downward by the conjoined action of the pectoralis minor, coraco-brachialis, and the short head of the biceps muscles. (Fig. 678.) If the fracture is within the limits of these ligaments, the process will either remain suspended between the ligamentous and muscular attachments, or be carried forward, leaving a considerable gap to be filled up by fibrous material, as in the Neill specimen.

* Malgaigne's Treatise on Fractures and Luxations, Packard's trans., p. 412.
† Chelius's Surgery, vol. i. p. 601.
‡ System of Surgery, vol. ii. p. 775.
§ General Archives of Medicine, 1840, vol. vii. p. 364.
|| Surgery, vol. i. p. 350.
¶ Holmes's System of Surgery, vol. ii. p. 775.
** Surgery, p. 843.

Prognosis.—This will depend upon the amount of damage sustained by other parts. When the organs of the chest have been severely concussed, or the contents of the axillary space much injured, or the soft parts extensively contused, a fatal termination will not be improbable. If, however, it is simply a fracture of the process, without other complications, recovery may be confidently expected, and with a useful arm. The union will be fibrous, not osseous. The dissection of Bransby Cooper's case,* the specimens in the Dupuytren Museum, and the scapula in the possession of Dr. Neill, all establish this condition; most probably the same kind of union existed in the case recorded by Hamilton,† in which the process was seen to follow freely the motions of the arm.

Fig. 678.



Fracture of the coracoid; the process drawn down by the pectoralis minor, coraco-brachialis, and the short head of the biceps muscles.

Treatment.—If the elbow is carried backward, and then lifted, with a view to gain for the process the direct support of the head of the humerus, the tension of the coraco-brachialis and biceps muscles will tend to displace the detached fragment. If the arm is carried across the chest, and so maintained, these muscles become relaxed, but the support of the head of the bone is lost; and hence the position which meets the demands of such a case is the vertical one, with the arm flexed, and either placed in the Fox apparatus or secured by a Velpeau bandage.

Fractures of the Neck and of the Glenoid Cavity of the Scapula.—The term *neck* of the scapula has two significations, according as it is viewed anatomically or surgically. The anatomical neck is the constricted part which supports the glenoid cavity. I know of no fracture of this portion of the bone, except the case referred to by Professor Spence,‡ of Edinburgh, which, however, was only partial, the whole of the glenoid cavity not being detached. The surgical neck includes the coracoid notch, and the existence of a fracture through this part of the bone, detaching the coracoid process with the articulating cavity, is established beyond all doubt. (Fig. 679.) Sir Astley Cooper claims to have had three cases. Duverney saw one, which was verified by dissection. Packard met with one case, in a little girl two and a half years old. Among 6485 cases of fracture treated in the Pennsylvania Hospital, one is recorded as a fracture of the neck of the scapula, though not verified by dissection. Dugas, of Georgia,§ reports two cases. When such a fracture exists, it is generally found associated with a like injury to the body of the scapula. Flower|| mentions one case in the museum of Guy's Hospital, and a second in the museum of the Royal College of Surgeons, and Duverney¶ supplies a third.

Fig. 679.

Position of a fracture of the neck of the scapula.—After Fergusson.

* Sir Astley Cooper on Fractures and Luxations, p. 380, American edition.
† Fractures and Luxations, p. 212.
‡ Edinburgh Medical Journal, 1863.
§ Southern Medical and Surgical Journal, vol. xv. p. 1859.
|| Holmes's Surgery, vol. ii. p. 776.
¶ Treatise on the Maladies of Bones, 1751, vol. i. p. 227.

Fractures may extend through the glenoid cavity, either riving it into pieces (Fig. 680) or chipping off a portion of its margin. Malgaigne has shown that this injury to the articulating cavity, when accompanied with luxation of the humerus, presents the same phenomena as fracture of the neck of the scapula; and it is highly probable that the former injury has sometimes been mistaken for the latter. Fracture of the neck must be the result of direct and concentrated violence. Mr. May, of England, gives one case—that of a lady—in which it was produced by muscular action alone,—in the effort of placing a necklace over the shoulder. If such was really the case, it could only be explained by a diseased condition of the bone. Fracture of the glenoid cavity may be produced by the head of the humerus being forcibly driven against its surface.

Fig. 680.

Stellate fracture of the glenoid cavity of the scapula.

Symptoms.—There will be a loss in the rotundity of the shoulder, with unusual prominence of the acromion, caused by the sinking of the humerus and by the contraction of the coraco-brachialis and the short head of the biceps muscle. The arm will be correspondingly increased in length. The degree of flattening and the elongation of the limb will be influenced by the extent to which the coraco-acromial and clavicular ligaments participate in the injury. If not torn, they will be competent to suspend the neck and resist the falling of the arm; but if torn, the elongation will be increased. If the hand is placed upon the acromion, and the limb raised up and rotated, crepitus will be felt, the coracoid process will be found to follow the movements of the arm and not those of the scapula, and the head of the humerus may be discovered in the axilla. The close relation of the axillary nerves and blood-vessels to the neck of the scapula exposes them to injury: in the three cases reported by Dugas the fracture was followed by complete paralysis of the limb, and by interruption to the circulation through its arterial trunks. Looking at the injury from a purely anatomical point of view, these last symptoms would seem to be almost a necessary sequence.

There are some symptoms which are common to this fracture and to luxation of the humerus, such as undue prominence of the acromion and flattening of the deltoid. The distinction may be established by pushing the arm upwards, when the deformity will readily disappear, but will reappear as quickly, if the case is one of fracture, whenever the support is withdrawn.

There is, however, a condition in which both fracture and luxation are present,—as when a portion of the rim of the glenoid cavity is split off and the head of the humerus glides into the axilla. Under such circumstances, if the bone is restored, it will immediately slip back into its unnatural position upon withdrawing the support of the hand. In this respect the fracture resembles a fracture of the neck of the scapula; but if it is remembered that in the latter injury the coracoid process moves with the arm, while in the former it remains fixed, the distinction will be apparent.

Fracture of the neck of the humerus is not likely to be confounded with fracture of the neck of the scapula, as in the former the rotundity of the shoulder is not lost, while in the latter it is very markedly flattened.

Treatment.—The humerus must be made to act as a splint. By pushing it upward and outward the neck of the scapula will be carried to the body of the bone, and in order to maintain the parts in position, a thick, wedge-shaped pad, five inches long and three inches wide, must be placed in the axilla, and the arm suspended in a sling and made fast to the body by a roller or a broad bandage; should the sling and bandage prove uncomfortable, they may be substituted by a Velpeau dressing. At the end of four weeks, passive movement must be made, in order to establish the functions of the joint.

Fractures of the Humerus.

Fractures of the humerus may be divided into three general varieties, namely, fractures of the upper extremity, fractures of the shaft, and fractures of the lower extremity.

Fractures of this bone are among the most common surgical injuries. Malgaigne* says that out of a total of 2358 fractures, 317 were of the humerus. Of 8667 fractures received into the Pennsylvania Hospital, 968 belonged to this bone. In 663 of these cases, 576 occurred in males and 87 in females; and in 529 instances in which the side was noted, 248 were on the right and 281 on the left side.

The largest number of cases of this fracture occur between the ages of ten and twenty, and the next largest, between twenty and thirty years of age: in the 663 cases above noted, 180 were met with in the first and 119 in the second decade. After the fortieth year, the number diminishes rapidly.

This does not correspond with the statement of Malgaigne, who alleges that their frequency increases up to sixty years of age, the largest number being between the ages of forty and sixty. Between sixty and eighty, as stated by the last-named author, the injury occurs with almost equal frequency in each sex.

The largest number occur during the winter months, a fact to be explained by the presence of ice and the frozen condition of the ground rendering the footing less secure.

We shall consider these injuries according to the divisions already named.

Fractures of the Upper Extremity of the Humerus.

By fractures of the upper extremity we mean all those which occur above the insertion of the latissimus dorsi and teres major muscles. These may be subdivided into those within the capsular ligament,—*intra-capsular*,—and those without,—*extra-capsular*.

First. **Intra-capsular Fractures.**—These may traverse either the head or the anatomical neck of the bone. When the head is broken, it is generally due to a gunshot injury,—a ball, shot, fragment of shell, or some other missile, penetrating the joint and not only producing a compound fracture by the presence of an external wound, but also often comminuting the bone. Such a fracture may occur, however, from the direct application of force to the shoulder, or even from force applied at the elbow or the hand, driving the head of the humerus violently against the glenoid cavity.

Diagnosis.—If there is an external wound, the nature of the injury may be determined by exploration with the finger or the probe. If no such wound exists, our diagnosis is a matter of inference rather than of certainty.

Prognosis.—When such a fracture takes place, the fragments, if comminuted, become necrosed, and may be discharged—after a long time—through the external wound, if one exists.

Fractures of the Anatomical Neck.—Although fracture of the anatomical neck is by no means a common accident, yet a sufficient number of cases are recorded to establish the reality of the injury. The line of separation is usually through the slight constriction or groove which separates the head from the tubercles, and falls, therefore, within the boundary of the insertion of the capsular ligament. (Figs. 681, 682.)

When the fracture is thus situated, the fragments never become united. The head of the bone lying loose in the joint and cut off from its blood-supply, we might expect that it would inevitably die, and, by causing inflammation and suppuration, be ultimately discharged. Yet, as stated by Gurlt,† there are no well-attested cases in which the head became a sequestrum and

* Treatise on Fractures, Packard's trans., p. 414.
† Gurlt on Fractures, vol. i. p. 745 (c).

was expelled from the articulation. The probability is that when thus separated it will become atrophied through the combined influences of attrition with the other fragment and of contact with the synovial fluid of the joint.

Fig. 681.

Fracture through the anatomical neck of the humerus.

Fig. 682.

Intra-capsular fracture of the neck of the humerus.—Malgaigne.

As in intra-capsular fractures of the hip-joint, so in similar ones of the shoulder there may be impaction; that is, the upper fragment, or the head, may be impelled into the cancellated tissue of the lower fragment and be inseparably intercalated, as shown by Robert William Smith, of Dublin, in his valuablé work on Fractures in the Vicinity of Joints. So deep may it be driven into the lower fragment as to split off one or both of the tuberosities. Fig. 683 represents an impacted fracture within the capsular ligament.

Symptoms.—The existence of an intra-capsular fracture must, in the very nature of things, be very difficult to diagnose. The presence of pain in the joint after a direct injury, loss of motion, indistinct crepitus, and the undisturbed relation of the different bony prominences about the articulation, without the evidence of any other fracture or displacement, constitute sufficient grounds for surmising the existence of the injury. In this enumeration of symptoms it is assumed that there has been no displacement of the fragments. If, however, the shaft of the bone should be drawn somewhat inward, as would most likely be the case, by the action of the pectoralis major, latissimus dorsi, and teres major muscles, or still more likely by the force which produced the fracture, then the end of the lower fragment might be felt, provided the swelling was not too great. A prudent surgeon, however, would not pronounce with too much certainty on the existence of this fracture.

Fig. 683.

Impacted intra-capsular fracture of the humerus.

When impaction exists, the nature of the accident is less obscure. The partial disappearance of the head, through its being buried in the upper part of the shaft, must leave a vacancy in the joint, and hence the shoulder becomes somewhat flattened, the acromion slightly less prominent, and beneath it there will be an appreciable hollow. For the same reason the arm will be shortened, and if the fingers be pressed from the axilla against the head of the bone while the arm is raised, the change in the size of the head of the humerus may be detected. Should the impaction break off a tuberosity, crepitus will be present, and may be recognized by placing one hand over the joint and with the other rotating the arm. Robert Smith* records a case of intra-capsular fracture in which the head of the bone was reversed, the cartilaginous surface being turned down and driven deeply into the cancellated structure of the lower fragment, and the broken surface directed upward towards the glenoid cavity. The broken surface of the upper fragment had become rounded so as to simulate the spheroidal form of the cartilaginous surface. In this case both tuberosities were broken. Nélaton furnishes two such cases;† and a similar one was in possession of Dr. Pope, of St. Louis. Hamilton‡ is disposed to regard these cases as the result, not of fracture, but of inflammatory softening and

* On Fractures in the Vicinity of Joints, p. 199. † Elements of Surgical Pathology, vol. i. p. 307.
‡ Fractures and Luxations, p. 218.

ulceration, in which view Prof. John Neill coincides. Certainly no such explanation will account for the case furnished by Robert Smith, in which fracture of the tuberosities existed. When inflammatory disease attacks the bone within the capsule of the joint, the head and not the neck generally suffers. As to the revolution of the head, either violence or muscular action would be quite sufficient to produce the change.

I have in my possession a fracture of the anatomical neck of the humerus in which the head has made a partial revolution, the cartilaginous surface looking inward, and I am quite confident that the displacement was produced by the long tendon of the biceps forcing the head in that direction as the shaft of the bone was drawn upward and outward.

Prognosis.—If the fracture passes entirely through the anatomical neck of the bone, severing the head from all connection with the lower fragment, union will not take place; the upper fragment will lie loose in the joint and become wasted, since it is deprived of all blood-supply. If, however, separation is not complete, or if some fibres of the capsular ligament still serve as a bond, consolidation is possible. Sometimes the fracture extends beyond the limits of the capsular ligament,—partly within and partly without: in such cases we may expect bony union to follow. A like favorable result will occur when the head is impacted in the spongy tissue of the lower fragment. In these cases it is the lower fragment which furnishes the reparative material.

Treatment of Intra-capsular Fractures.—In compound comminuted fractures of the head of the humerus, such as are produced by shot wounds, two courses of treatment are open to the surgeon, namely, excision and expectancy. In exceptional cases the latter may be adopted with propriety, —that is, when the comminution is confined strictly to the head of the bone, not extending beyond the limits of the anatomical neck. After suppuration is once established, the necrosed fragments may be picked away and the case do well. When, however, the lesion extends into the tuberosities and the upper end of the shaft, excision will be the proper course: the dangers which attend a prolonged suppuration under the expectant plan of management are too great to warrant its adoption. Whatever plan of treatment is pursued, the arm should be brought to the side, the forearm flexed across the chest, and an external concave splint applied, capping the shoulder and extending to a point three inches above the elbow, both splint and arm being fixed in position by a broad bandage or a roller passed round the body, and the hand supported in a sling. When the fracture extends through the anatomical neck of the bone, the shaft must be carried up to the head of the bone and there retained. This is best accomplished by placing a small wedge-shaped pad in the axilla, with the base above, applying the external concave splint in the summit of the shoulder and outer part of the arm, and securing all by a Velpeau bandage.

Second. **Extra-capsular Fractures.**—These may be either impacted or non-impacted. The varieties to be considered are the following: 1st, fractures of the great tuberosity; 2d, separation of the epiphysis,—the epiphysis consisting of the head and tuberosities; 3d, fracture of the surgical neck.

Fractures of the Great Tuberosity.—Such fractures are the result, usually, of direct force, or of force applied when the arm is along the side of the body. A portion of the head may be detached with the tuberosity. Robert Smith, Sir Astley Cooper, and Hamilton furnish examples of these fractures.

Symptoms.—If the tuberosity is entirely detached, it will be drawn backward by the conjoined influence of the supra-spinatus, infra-spinatus, and teres major muscles, and the lower fragment or the shaft of the bone will be carried inward by the subscapularis and forward by the pectoralis major muscle, producing what is regarded by Malgaigne as a form of luxation. As the tuberosity contributes in some degree to the rotundity of the joint,

this feature of the shoulder will be measurably lost, and the acromion will become correspondingly prominent. The shaft and the tuberosity being drawn in opposite directions, the articulation will be increased in breadth, and, if the swelling is not too great, both the head of the bone and the tuberosity may be felt,—the first near the coracoid process, and moving when the arm is rotated, the second some distance back, and not responding to such movements,—while between them a depression may be discovered. The patient will be unable to raise the arm to any considerable extent, or to rotate it outward, and severe pain will be experienced when it is moved. Should the line of fracture traverse the insertion of the muscles on the dorsum of the scapula, the tuberosity may not become entirely detached from the bone, in which event the symptoms detailed may not be present. Under such circumstances the diagnosis would be necessarily rendered less certain.

Prognosis.—The difficulty in securing the accurate coaptation of the fragments will render bony union improbable. Robert Smith believes that the parts, when much separated, are always connected by ligamentous tissue.

Treatment.—The shoulder must be carried back by a posterior figure-of-eight roller, in order to bring the shaft to the tubercle, and the arm suspended in a sling, and made fast to the body by circular turns of a bandage.

Fracture through the Superior Epiphysis.—This fracture is confined to an early period of life, being seldom met with after the eighteenth year. It is usually produced by falls upon the shoulder, and is not unfrequently mistaken for a luxation of the scapulo-humeral joint. The head of the bone may become completely disengaged from the shaft, or the latter, by its rounded extremity, may cling to the concavity of the former after the manner described by Professor Moore. (Fig. 684.)

Fig. 684.

Incomplete separation of the epiphysis of the humerus.—Moore.

Symptoms.—The signs which indicate the existence of this fracture are loss of power in the limb (the arm hanging helpless by the side), and the presence of a prominence immediately above the coracoid process of the scapula. This prominence, which is the upper end of the lower fragment, is not sharp and irregular as in fracture through the surgical neck of the bone, but is smooth, and moves with every motion imparted to the arm. In order to obtain crepitus, it is necessary first to push the shaft of the humerus back, and afterwards to communicate to it a rotatory movement. The sound will be much softer and less distinct than that which is experienced in ordinary fractures. This accident may be distinguished from a dislocation by the shoulder still retaining its rotundity, and by the elbow not projecting to any marked degree from the side of the body.

The *treatment* does not differ from that proper to fracture of the surgical neck of the bone.

Fracture through the Surgical Neck of the Humerus.—This fracture may be located at any part of the bone, from the tuberosities to the insertion of the latissimus dorsi and teres major muscles. Sir Astley Cooper extended the

limits of this injury as far as to the attachment of the deltoid muscle. Under this head are sometimes included fractures through the epiphysis.

Fractures of the surgical neck are very common accidents, especially in persons somewhat advanced in life, or between forty-five and fifty-five years of age. They are produced by direct violence, received when the arm is near to the chest. Their direction is rather transverse than oblique (Fig. 685), resulting, no doubt, from the diminished length of the osseous arches which exist near the extremity of the bone.

Fig. 685.

Fracture through the surgical neck of the humerus.

Symptoms.—The arm, after such an injury, is powerless. Any movement of the bone causes pain, sometimes of a very severe shooting character, and extending to the fingers, in consequence of the axillary plexus of nerves being injured by the displaced bone. The limb will usually be found shorter than its fellow, the degree of shortening being greatest when the fracture is very oblique. In comparing the length of the two limbs, the measurement should be made from the acromion process to the external condyle of the humerus.

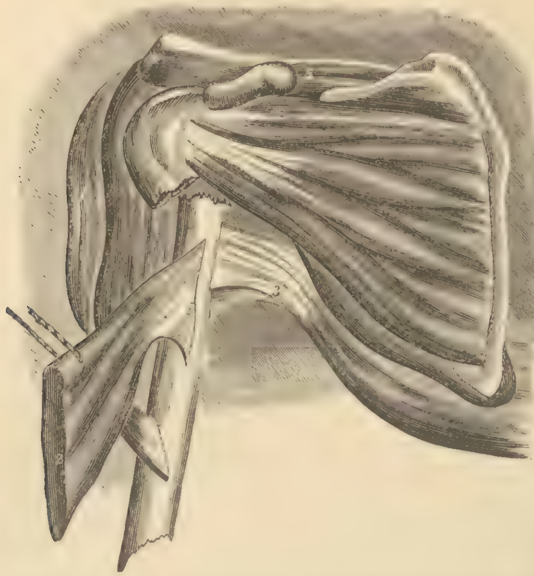
In addition to the above-named symptoms, there will be crepitus, which may be discovered by making traction upon the arm and then rotating it, while the shoulder is embraced between the thumb in the axilla and the fingers on its external surface. It sometimes happens that the lower is impelled into the cancellated tissue of the upper fragment, especially when the fracture is near the connection between the epiphysis and diaphysis, thus making an impacted fracture, the recognition of which may be a very difficult matter. If after an adequate injury the arm is found disabled, somewhat shortened and painful, and if, in addition, a slight crepitus can be discovered by fixing the head of the bone while the limb is forcibly rotated, there will be just ground for suspecting the existence of an impacted fracture.

Displacement.—The displacement which follows a fracture through the surgical neck of the humerus is confined, when it does occur, principally to the lower fragment, which will be drawn inward and upward. The agents concerned in these two displacements are the sternal portion of the pectoralis major, the latissimus dorsi, and the teres major muscles. These draw the arm to the side or inward, while it is pulled upward by the deltoid, the clavicular part of the pectoralis major, and the coraco-brachialis, together with the biceps and triceps muscles. The upper fragment undergoes little change, but may be drawn inward by the action of the subscapularis, infra-spinatus, and teres minor muscles. (Fig. 686.) The end of the lower fragment may sometimes be felt through the skin, near the coracoid process. There is a specimen in the museum of the University of Pennsylvania in which the end of the bone is united to the coracoid. Sometimes the lower fragment is forced outward, penetrating the deltoid muscle, an occurrence which I witnessed very recently. Lastly, the inferior fragment may be carried directly backward, as was seen in a case of Dupuytren's. When the displacement is purely the result of muscular action and the fragments have slid past each other, we may expect the lower one to assume the upward and inward position; any other must be due to the impetus given by the fracturing force. In the majority of these fractures there is very little displacement, because the direction of the separation is, approximately at least, transverse, and the long tendon of the biceps, unless thrown from its groove, will resist the disarrangement of the broken pieces.

Diagnosis.—Fractures of the surgical neck of the humerus have been confounded with dislocation, and when the swelling is great such an error is not unlikely. Some light may be thrown on the case by ascertaining the position of the arm at the time of the accident. If it was abducted and with the elbow directed away from the body, a luxation is probable; if it was close

to the side, a fracture. In luxation, the acromion process is more prominent than in fracture. In fracture, the ecchymosis is chiefly seen over the deltoid

FIG. 686.



Fracture through the surgical neck of the humerus: 1, deltoid muscle; 2, pectoralis major, turned down from its origin; 3, latissimus dorsi, attached to the humerus; 4, subscapularis muscle; 5, supra-spinatus muscle.

prominence, being confined to this region by the attachment of the deltoid fascia; in luxation, it is usually found on the inner part of the arm, having been conducted in this direction by the pectoral and axillary fasciæ. In fracture, the reduction is easily effected; in dislocation, it is more difficult. In the former, there is a strong tendency to displacement after adjustment has been accomplished; in the latter, no such disposition exists. In fracture, again, we can elicit crepitus; not so in luxation. There is a sound sometimes heard after severe contusions about the shoulder, when the arm is moved, which resembles crepitus. This has a synovial, thecal, or bursal origin, but it is neither so dry nor so rough as that from bony crepitus, and when once learned the distinction is not very difficult to recognize. Lastly, in fracture, when the head of the bone is touched and the arm at the same time rotated, no movement will be imparted to the upper fragment, while in luxation the reverse will be true. In case of impaction, of course this test will fail. In all these fractures the use of ether will assist us greatly in resolving any doubts which may exist.

In young subjects, before the osseous union of the epiphysis and diaphysis, a fracture may pass through the connecting cartilage. In such a case the crepitus is less harsh, from the nature of the broken surfaces, and is in its character more like the impression received from the inflamed sheaths of tendons or the interior of a bursa. The other symptoms will not differ from those already described as belonging to fractures of the surgical neck.

PROGNOSIS.—A favorable result may be confidently expected in all cases of simple fracture of the surgical neck, both as to the union and the usefulness of the limb. Hamilton* records eleven cases of such fractures which he had under observation. In eight the limbs were perfect; in three there was deformity, but with a useful arm; and in one no union took place. My own experience does not furnish a single example of failure in the con-

* Fractures and Luxations, p. 227.

solidation, although I have occasionally seen considerable rigidity about the joint where severe contusion of the soft parts had been experienced at the time of the fracture, and which rendered the patient unable for several months to carry the arm to the head.

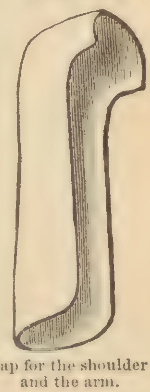
Treatment of Extra-capsular Fractures.—The dressing which, in my hands, has proved most satisfactory, consists of two splints,—one an internal angular (Fig. 687), and the other a piece of binders' board, long enough to ex-

Fig. 687.

Author's internal angular splint.

tend two inches above the acromion, down almost to the external condyle, and wide enough to include, when moulded into shape, the outer, posterior, and anterior surfaces of the arm. (Fig. 688.) The fracture being reduced, a roller is carried from the fingers up to the shoulder. The internal angular splint, well padded, is next placed along the inner side of the flexed arm, extending well up into the axilla, the skin of which should be protected by a pledget of soft, clean cotton. The binders' board should now be well soaked in hot water until perfectly pliable, when, a few short vertical slits being made in its upper extremity, it can be neatly moulded to the shoulder and arm. Some cotton must be next placed beneath its upper and lower extremities, after which, with a second roller beginning at the hand, these splints are to be firmly bound to the arm, finishing with a few turns of the spica of the shoulder. The arm is now placed along the side of the body and lightly secured to the same by a strip of muslin, and finally the hand and wrist are to be supported in a sling. The sling should not include more than the hand and the wrist, as the weight of the arm contributes to the extension. (Fig. 689.)

Fig. 688.



Cap for the shoulder and the arm.

By this method the axillary wedge-shaped pad of Sir Astley Cooper is discarded. This pad was designed to act upon the lower fragment and keep it out, the base of the pad being placed upward. I have never seen the necessity for its use. When the arm is brought to the side, the pectoralis major, latissimus dorsi, coraco-brachialis, and the short portion of the biceps muscles are relaxed, and can have little if any influence in drawing the lower fragment inward. Again, it will be seen that I have directed the arm to be bound to the body by a single strip, instead of by the usual roller, which is frequently a source of uncomfortable restraint to the patient.

Another plan of treating these fractures, and one which has given me very satisfactory results, is the following: first cover in the entire arm with a spiral reversed roller, and then mould to its anterior, outer, and posterior surfaces a splint of binders' board, with a cap for the shoulder, after which the arm is flexed and placed against the side, with the forearm across the chest. It only remains to bind it to the body by a few spiral turns of a bandage and to support the hand in a sling. By this method the internal angular splint is dispensed with, the body of the patient taking its place.

Mr. Tyrrel, in a case of fracture through the surgical neck of the humerus, was obliged to carry the arm away from the body, and to maintain it so on a rectangular splint, in order to overcome the outward displacement of the upper end of the lower fragment.

I was obliged, under like circumstances, to resort to a similar position in the case of a woman whom I attended with Dr. Watson, of this city. The upper end of the lower fragment was persistently drawn out by the deltoid muscle, and the deformity was only overcome by bringing the arm at a right angle with the body, and, after applying the dressing, keeping it in this position by a proper support until the tendency to displacement passed away. I have seen the same deformity overcome by first abducting the arm, while in this position, and bandaging it firmly to the internal splint, and afterwards making fast the external splint, when the limb was brought again to the side.

Fig. 689.

Dressing for fracture of the surgical neck of the humerus.

The union requires from four to eight weeks, and it is necessary about the fourth week to begin passive motion.

Compound fractures of the surgical neck are to be treated as similar injuries elsewhere, namely, by adjusting the fragments, closing the external wound, and placing the arm on the splints already described. If the wound is large, some caution is necessary in regard to its closure. It must be carefully watched, and on the earliest evidence of the presence of inflammatory accumulations a free vent for their escape should be provided. If there is a sharp point belonging to the lower fragment, with a tendency to displacement, and provoking much irritation, it should be turned out of the wound and the offending portion removed.

Fractures of the Shaft of the Humerus.

These fractures may take place at any point between the surgical neck and the condyles of the bone. There is some discrepancy among authors as to the most common location. The lower third, in my own experience, has generally been the seat of fracture.

The direction of the fracture is generally oblique, sometimes transverse. The separation may be either complete or incomplete. The latter condition is met with occasionally in young subjects.

Causes.—Generally the causes are direct violence. Many cases of fracture by muscular action alone are recorded; indeed, this bone seems to be particularly distinguished for such injuries. Gross* saw a case where the humerus was broken by simply throwing a chip. Liston† records one which was broken by merely stretching out the arm quickly. Bryant‡ furnishes a case in which the fracture was produced in a marital embrace. I have seen the accident once occur from the trifling effort of getting into bed. Persons sometimes make a trial of strength by sitting on opposite sides of a table, placing their elbows on it, and, grasping each other's hands, each struggling to turn outward the arm and wrist of his competitor. In such contests the humerus has been snapped asunder, instances being furnished by Malgaigne, Lonsdale, Hamilton, and others. Fractures of the humerus have been known to occur to the child during parturition.§

Symptoms.—There will be deformity, unusual mobility, and crepitus. The deformity will differ according to the seat of fracture. When broken from muscular action, the fragments do not separate, save in exceptional cases, the periosteum and the serrations keeping them in contact. Should the break

* Surgery, vol. i. p. 981.
† American Journal, November, 1836, p. 249.
‡ Surgery.
§ Hamilton on Fractures, etc., p. 234.

occur above the insertion of the deltoid muscle, the lower fragment will be tilted outward and drawn up by this muscle, while the upper fragment will be drawn inward by the pectoralis major, latissimus dorsi, and teres major muscles.

If the fracture takes place below the insertion of the deltoid, the upper fragment may be little changed, as the deltoid on the one side, and the pectoralis major, the latissimus dorsi, and the teres major on the other side, antagonize one another. The lower fragment may be drawn somewhat upward and inward by the biceps and triceps muscles. It will, however, be found in practice that the direction of these fractures and the influence of the fracturing force will often neutralize muscular action, and present us with a different relation of the fragments from that just stated. When the fracture occurs through the lower third of the bone, the lower fragment is prone to slip behind the upper one, in which case the shortening, through the contraction of the biceps and triceps muscles, becomes very marked. (Fig. 690.) The tendency, so far as muscular action is concerned, will always be to produce shortening. In a specimen in my possession, the overlapping amounts to almost two inches.

FIG. 690.

Fracture at the lower third of the humerus, with overlapping.

PROGNOSIS.—In simple fractures, a rapid cure may be confidently anticipated in from four to five weeks; yet it must never be forgotten that a very large number of the cases of ununited fracture occur in this part of the bone. There is no explanation for this to be found in any peculiarities connected with the bone, so that there is reason to believe that in some instances non-union is due to an imperfect immobilization of the fragments. Of course these remarks are not designed to apply to cases of compound or comminuted fractures of the bone, as under such circumstances we have a sufficient cause for any failure to consolidate which may follow.

If the fractured ends are entirely displaced from each other, the soft parts participate in the injury, and we may expect considerable inflammatory swelling: even abscesses have followed these accidents. The rigidity of the shoulder-joint and elbow-joint,—especially of the latter,—the result of a fixed flexed position, is certainly greater than that of the knee and the hip in fractures of the thigh. An examination of a large number of fractured humeri convinces me that, when the separation is oblique, there is almost always some degree of deformity by overlapping, which, however, does not impair the usefulness of the limb to any appreciable degree.

Another danger to which the arm is exposed in these fractures is a paralysis of certain groups of muscles. Should the musculo-spiral be damaged where it passes round the humerus, or lower down, where its posterior interosseous branch is given off, the extensor muscles will become powerless, as also will the supinators; the hand will drop and become pronated. (Fig. 691.) This condition may remain permanent. A lad ten years of age was brought to the clinic of the University with this condition following a fracture of the humerus. As the absorption of the redundant callus took place, and under the stimulus of an electro-galvanic current, his improvement was quite noticeable.

There is reason to believe that even the brachial artery may be compressed by one of the fragments, and give rise to sloughing. Hamilton relates the case

of a physician who was prosecuted for malpractice, before a court in Tioga County, New York, in consequence of a result of this kind, which had been improperly attributed to the maladroit use of splints.

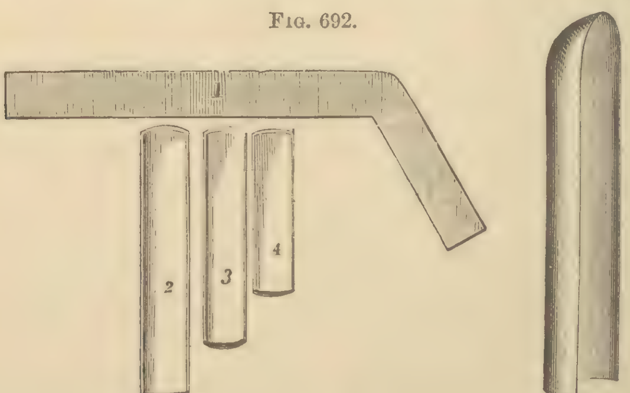
Fig. 691.

Paralysis of the extensors of the hand, or wrist-drop, after fracture.

Treatment.—The indications are, first, to control muscular action; second, to secure muscular relaxation; third, to immobilize the fragments; and last, to prevent articular stiffening. The first is effected by applying a spiral reversed roller as far as the elbow: if there is overlapping, an assistant should make extension by seizing the arm just above the elbow-joint, the forearm being flexed at a right angle, while a second makes counter-extension by grasping the shoulder, the surgeon at the same time coaptating the parts. If any difficulty is experienced in restoring the limb to its proper length, an anæsthetic should be employed, so as to remove all muscular resistance. As soon as the adjustment has been made, the roller should be continued up to the shoulder. This bandage is exceedingly important. It secures quietude of the muscles, is a capital support to the fracture, and removes as well as prevents swelling.

The second indication, that of effecting muscular relaxation, can be carried out only very imperfectly. With this object, the forearm is flexed to somewhat less than a right angle. This position relaxes both the biceps and the brachialis anticus muscle, and only to a moderate degree extends the triceps. It is also necessary to control the movements of the forearm, upon which these muscles are inserted. To maintain the arm in the proper position, and at the same time to immobilize the fracture, there will be required an internal obtuse angular splint, long enough to extend from the axilla to the ends of the fingers, with an opening cut at the angle, in order to relieve the internal condyle of the humerus from pressure; and a concave splint of binders' board, reaching from the summit of the shoulder to the external condyle of the humerus, and moulded into form by being softened in hot water. If the binders' board cannot be obtained with which to make the concave splint, the latter may be substituted by three short pieces of light wood. (Fig. 692.) These splints, being well padded, are applied as follows:

Fig. 692.



Angular, concave, and short straight splints for treating a fracture of the shaft of the humerus.

the angular splint is laid along the inner side of the arm and the forearm, and the concave one is placed over the outer, posterior, and anterior surfaces, after which a roller is carried from the hand to the shoulder, binding the

splints firmly to the limb, and terminating by a few turns of the spica of the shoulder. The dressing is completed by suspending the hand in a sling. (Fig. 693.)

Fig. 693.

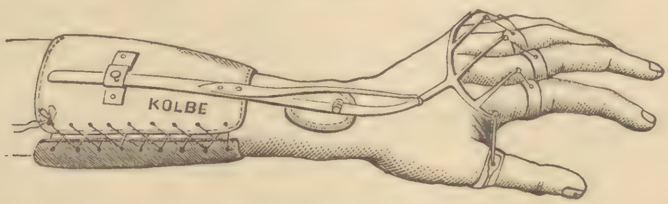
Dressing for fracture of the shaft of the humerus.

When the short splints are used, the largest is to be laid upon the outer surface, the shortest upon the anterior surface, and the one intermediate in length along the posterior aspect of the arm, all being fastened, as in the first instance, by the ascending turns of the roller.

In order to overcome shortening, several devices have been resorted to, such as the crutch of Lonsdale, the ratchet-splint, the adhesive plasters of Martin, of Boston, and the elbow weight of Dr. Clark; but all such appliances, however ingenious, will prove unsatisfactory in consequence of the mobile nature of the shoulder.

The paralysis incident to nerve-pressure may disappear as the redundant callus is absorbed; but when this is not the case, an apparatus for the support of the hand may be applied with advantage. (Fig. 694.)

Fig. 694.



Apparatus for wrist-drop applied.

Fractures of the Lower Extremity of the Humerus.

The diagnosis of injuries occurring at the lower end of the humerus demands the most accurate knowledge of the anatomy of the elbow-joint. I never approach cases of this nature without a certain degree of anxiety. Such fractures are often compound, sometimes comminuted, and attended with much swelling and inflammation of the joint, as well as injury to the soft parts. The varieties of fracture met with here are the *supra-condyloid* and the *condyloid* fractures.

Supra-condyloid Fractures.—These include two varieties,—one just above the limits of the expanded condyles, and the other through the lower epiphysis, the latter being very rare. (Figs. 695, 696.) Their symptoms are so similar that it is a very difficult task to distinguish the one from the other. The first, or that through the lower part of the bone, may be transverse or oblique. Sir Astley Cooper thought that it was generally oblique and ran in a direction downward and forward. This accords with my own observation; though there are not wanting examples in which the reverse is true, namely, the fracture running downward and backward. The subjects of

this injury are usually young. Of sixteen cases noticed by Hamilton, ten were in children under ten years of age.

Causes.—A fracture, either above the condyles or through the epiphysis, is generally the result of force applied directly to the elbow, and occasionally of force transmitted through the bones of the forearm.

Symptoms.—There will be preternatural mobility, shortening of the arm, crepitus, and deformity. Two projections may be discovered, the one in front formed by the lower end of the upper fragment, and the other posteriorly, often the larger of the two, formed by the upper end of the lower fragment. The fracture occurring so near to the articulation is liable to be mistaken for a luxation of the elbow-joint. A consideration of the following points will enable the practitioner to establish the distinction:

Fig. 695.

Fracture of the epiphysis, with irregular surface.—Hamilton.

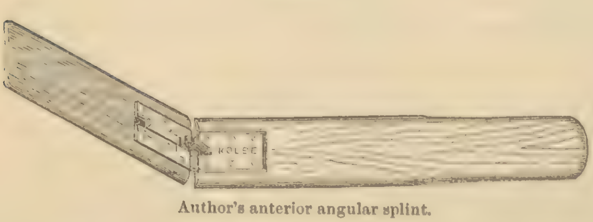
Fig. 696.

Fracture through the epiphysis: separation smooth.—Bryant.

FRACTURE.	DISLOCATION.
In fracture, there is shortening of the arm.	In dislocation, there is no shortening of the arm.
The condyles of the humerus and the olecranon process are in the same line.	The olecranon is above the line of the condyles.
There will be crepitus.	There is no crepitus.
The end of the upper fragment is above the bend of the elbow.	The end of the humerus is below the bend of the elbow.
The end of the upper fragment is moderately broad, and, if the fracture is not epiphyseal, irregular in its outline.	The end of the upper piece is broad and comparatively smooth.
Reduction is easily effected by extension and counter-extension; but the deformity reappears on the withdrawal of those forces.	Reduction requires the exercise of considerable force, and when once accomplished there is no tendency to a return of the deformity.
Forearm is very movable.	Forearm is fixed, or admits of little movement.

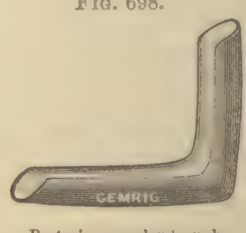
Treatment.—Extension and counter-extension being made, in order to bring the lower end of the bone into position, the forearm is placed at a right angle with the arm, and firmly covered from the fingers to the axilla with a roller bandage. Two well-padded rectangular splints are next placed as follows: one (Fig. 697) is laid along the anterior aspect of the arm, extending from the shoulder to the ends of the fingers, and the other, in the form of a trough,—moulded from binders' board, leather, or gutta-percha,—is placed on the posterior aspect of the arm, extending from the middle of the arm to the middle of the forearm, and deep enough to receive half the circumference of the arm. (Fig. 698.) These splints are to be secured by a second

Fig. 697.



Author's anterior angular splint.

Fig. 698.



Posterior angular trough.

roller and the arm placed in a sling. I am confident that we have a much greater security against displacement in the use of two splints so disposed, than by any other method.

At the beginning of the third week, passive motion should be carefully commenced, the arm being firmly grasped at the seat of fracture with one hand, while the forearm is gently flexed and extended with the other.

Condyloid Fractures.—These fractures are variously situated. 1. They may run transversely across the base of the condyles; 2. they may pass vertically between the condyles,—intercondyloid; 3. their direction may be both transverse and vertical, separating the condyles from the shaft of the bone and from each other; 4. the internal or the external condyle may be broken; and, 5, the epicondyle may be detached from the internal condyle. There are no fractures through the external epicondyle as yet satisfactorily established.

Fractures about the elbow-joint are not unfrequently followed by impaired motion and by deformity, notwithstanding the most judicious management; and the patient should always be informed of the probability of such a result. The inflammation and swelling which rapidly follow these injuries often mask the accident.

Fracture across the Base and between the Condyles.—In this variety of fracture (Fig. 699), first noticed by Desault, there is a separation both between and through the base of the condyles, making three fragments,—properly a comminuted fracture, and one of rare occurrence. Malgaigne was able to collect eight cases, and Hamilton has met with the accident only six times.

FIG. 699.

Transverse and vertical fracture of the condyles of the humerus.—Malgaigne.

SYMPTOMS.—The symptoms are an increased breadth of the elbow in consequence of the separation of the condyles, with mobility of the latter when pressed in opposite directions. There is also a free antero-posterior mobility of the condyles, which does not affect the shaft of the humerus. Crepitus may be recognized when the condyles are moved either back and forth or when they are forced together. The radius and ulna, losing their support, are displaced backward, and form an unnatural prominence on the back of the arm.

The cause of this fracture, as far as can be gathered from the description given by patients, is violence applied to the posterior part of the elbow when the arm is flexed, thus driving the olecranon forward against the condyles.

PROGNOSIS.—Stiffening and even firm anchylosis of the joint may be anticipated, although the surgeon should not despair of securing an opposite termination.

Fractures of the Condyles.—Each condyle is surmounted by a bony projection, which by American surgeons is termed the epicondyle. A fracture, therefore, at this portion of the bone may be articular or non-articular, according as it involves the condyle proper or its epicondyloid prominence. These accidents are always grave, but not to the same degree as the intercondyloid fracture just described. A large proportion of these fractures occurs in childhood, or during early adolescence.

CAUSES.—These are generally falls or blows, in which the force is applied either on the side or on the point of the elbow, and in some cases is transmitted to the humerus from the hand, through the bones of the forearm.

PROGNOSIS.—In all fractures affecting the condyles or the epicondyles, we may expect more or less stiffening, as a result of inflammatory deposition both within and without the articulation. This, however, constitutes only a temporary disability, as the rigidity is usually amenable to treatment. In the management of all these fractures, the flexed position of the arm is the one which must be maintained.

Fractures of the Internal Condyle.—The external condyle is more frequently broken than the internal. This is corroborated both by Malgaigne and by Hamilton; though Desault, who was the first to describe the injury, entertained, in common with Sir Charles Bell and Sir Astley Cooper, the opposite opinion.

The direction of the fracture is oblique to the longitudinal axis of the limb, and will involve the joint to a greater or less extent, according to this obliquity. In most cases it reaches the middle of the olecranon surface. (Fig. 700.)

Fig. 700.

Fracture of the internal condyle.

Symptoms.—There will be pain and rapid swelling; the latter sometimes so great as to obliterate all the characteristic features of the articulation. If the arm is extended, it will incline inward. The breadth of the elbow may be increased. This depends, however, upon the amount of displacement, as in some instances the ligaments still hold the condyle in nearly its normal situation. By grasping the epicondyle between the thumb and fingers, the condyle, if detached, will be felt to move independent of the humerus, and crepitus may at the same time be felt. The olecranon will be drawn upward and backward, and with it the condyle, forming a very marked prominence on the back of the arm, especially when the forearm is extended. If a line is extended from the acromion process to the internal epicondyle, it will exhibit a certain amount of shortening as compared with the external condyle.

Fractures of the External Condyle.—These, like those of the internal condyle, are, save in exceptional cases, injuries peculiar to the young,—not often occurring after twelve or fifteen years of age. They are oblique in their direction, and include the articulating surface for the head of the radius (Fig. 701), or, passing still more to the inner side, may involve the articulating surface appropriated to the ulna.

Fig. 701.

Fracture through the external condyle of the humerus.—Smith.

Symptoms.—Pain, swelling, deformity, crepitus, and mobility of the detached part are the signs of this accident. The pain is very acute when the joint is moved. There is increased breadth of the joint, the broken condyle being drawn either outward or forward, or upward and backward, in spite of the supinator and extensor muscles. If the latter displacement follows, the arm will be slightly flexed and an unusual prominence felt posteriorly. When the arm is extended, it will incline to the radial side, and the degree of this inclination will be increased in proportion as the line of fracture encroaches upon the articulating surface of the ulna. If the radius is not entirely detached from the condyle, which sometimes occurs, it will follow the latter in its displacement; and the same is true of the ulna.

Diagnosis.—The only injury with which fractures of the condyles are likely to be confounded is dislocation. A consideration of the following points will serve to establish the distinction:

In fracture, extension of the arm will remove the deformity, but it will immediately reappear on taking away the traction force. In luxation, a greater amount of force is requisite to effect the reduction, and when the bones are once restored they so remain. In fracture, there is crepitus; in luxation, there is none. In fracture, there may or may not be flexion of the arm; in posterior luxation, flexion is always present. In luxation, the epicondyloid eminences are always in a line; in fracture, they do not correspond,—one being higher or lower than the other.

Prognosis.—This fracture may be expected to unite firmly in a period of

four weeks, though there are numerous instances of ligamentous or fibrous union. Some stiffness of the articulation may be anticipated, the degree of which cannot be predetermined; yet by judicious movements much of this will wear away, and a good arm may be confidently expected.

Fractures of the Internal Epicondyle.—Although there are two epicondyles, there are no well-authenticated cases of fracture of the one surmounting the external condyle, and therefore I treat only of fracture of the one belonging to the internal. Granger* first described this injury in the year 1818.

Causes.—The epicondyle is an epiphysis, and the fracture, in most cases, occurs in childhood, before its bony consolidation with the condyle has taken place. It is occasionally produced by muscular action alone. This is not surprising when we consider that the origins of the flexor muscles of the forearm concentrate upon this point, and that they are capable of exerting great power when the arm is put out to defend the body against a fall. Direct blows frequently occasion fracture of this process. (Fig. 702.)

Fig. 702.

Fracture of the internal epicondyle.

Symptoms.—There will be pain, swelling, discoloration, mobility, and crepitus. The last can be ascertained by seizing the process between the thumb and fingers and pressing it in opposite directions. The fracture may not disable the patient from performing to some extent the different movements of the arm. The deformity or displacement is, in most cases, downward and a little forward, and is due to the action of the pronator and flexor muscles.

Granger states that in this fracture the ulnar nerve may be damaged, giving rise to disordered sensibility and to loss of power in the parts supplied by its branches, as shown by the altered sensibility on the inner side of the hand and along the ring and little fingers, and by the loss of power in the abductor and the flexor brevis minimi digiti muscle, which occurred in some of his cases. This condition was sometimes attended with an eruption of vesicles over the affected parts, somewhat akin to the herpes zoster which is occasionally seen accompanying an attack of neuralgia. It is not probable that these effects can result from a displaced epicondyloid fragment, as the nerve lies in a groove deep between the internal condyle and the olecranon process of the ulna, and quite secure from injury by such a displacement. I cannot help thinking that they must have been due to contusion of the nerves by the force producing the fracture, or from the line of separation involving the condyle itself. Certainly I have never witnessed such a condition, nor am I acquainted with any similar cases narrated by other observers.

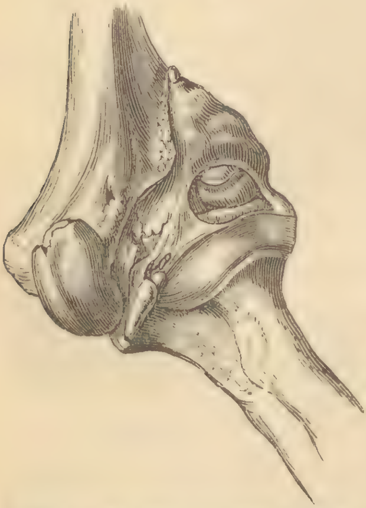
Prognosis.—Complete reduction is rarely effected, and stiffness of the articulation may be looked for, not necessarily from involvement of the joint, but from the inflammatory deposit about the origin of the pronator and flexor muscles of the forearm. The abridged movement will not be permanent, but will wear away under appropriate treatment, a process, however, sometimes requiring years for its accomplishment.

Treatment of Fractures at the Lower Extremity of the Humerus.—In all condyloid and epicondyloid fractures the three great indications are to control inflammation, to secure a proper adjustment of the fragments, and to prevent, as far as possible, anchylosis of the elbow-joint. When there is much pain and inflammatory swelling, the application of leeches about the articulation will produce the happiest effects; and when these cannot be obtained, lead-water and laudanum should be freely applied to the parts.

* Edinburgh Medical and Surgical Journal, 1818, vol. xiv. p. 196.

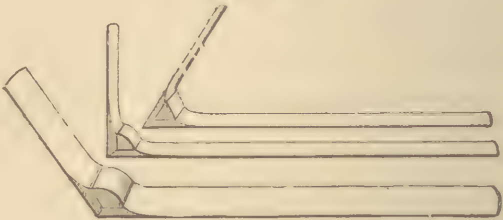
During the urgency of the inflammatory symptoms, and while lotions are being used, it has been recommended not to encumber the arm with any apparatus, but simply to support the limb upon a pillow. If the surgeon could always have the patient under strict surveillance, there would be no objection whatever to this practice. Except, however, in hospitals, this is not possible; and consequently I prefer placing the arm immediately in a permanent dressing. With few exceptions, the flexed position is the one adopted by surgeons as best adapted to the treatment of these fractures. The angle, however, should be very obtuse; otherwise, in fractures of the external condyle particularly, there will be an upward and backward displacement (Fig. 703), which will be found to leave an unnatural prominence or a deformity on the outer aspect of the joint. This is always increased by the right-angled position of the arm.

Fig. 703.



Fracture of the external condyle, with displacement upward and backward.—Malgaigne.

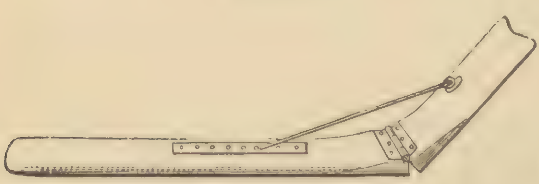
Fig. 704.



Anterior angular splints of different angles.

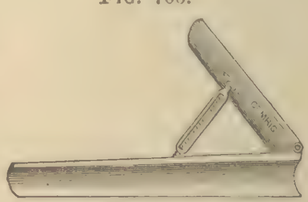
In order to maintain the arm in the flexed state, it is necessary to employ the anterior angular splint. There are three varieties of this splint,—the fixed, the movable, and the trough-shaped. The first two are constructed so that one form can be worn on the inside of the arm and the other on its anterior surface. My preference is very decidedly in favor of the anterior angular splint, as it is better suited to prevent posterior displacement of the fragments than is the internal angular one. When this form of the splint is used, it is best to have several of different angles (Fig. 704), so that the position of the joint may be changed from time to time after the consolidation of the bone is sufficiently advanced to prevent displacement. If the two parts of this splint are joined by an articulation, the angle can be changed at pleasure, and one can be made to accomplish the office of a number. The alteration of the angle is sometimes regulated by a rod having a hook at its free end, which fastens

Fig. 705.



Articulated anterior angular splint.

Fig. 706.



Anterior angular splint, with a Stromeyer screw.

into the holes of a cleat. (Fig. 705.) This rod is sometimes substituted by a Stromeyer screw. (Fig. 706.) The presence, however, of either the rod or the screw rendering the application of a roller somewhat inconvenient, I

employ a ratchet-hinge. (See Fig. 697.) Professor Gross uses a long tin case, well padded, and extending from the axilla to the carpus.

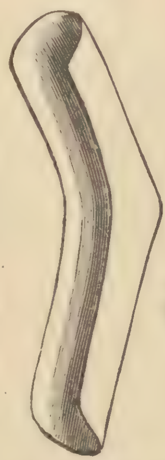
To apply the dressing, the arm should be flexed to a right angle and covered with a spiral reversed roller from the fingers to the axilla. This by some surgeons is deemed unnecessary, but with them I cannot agree. In no other way can involuntary muscular action be so conveniently controlled, and, as the irritation from this cause is frequently very distressing, the bandage becomes a source of great comfort to the patient. Again, when judiciously applied, the roller serves to limit the swelling, and in cases where the condyles separate from each other it assists in binding them together.

After this preliminary bandage, the anterior angular splint should be placed on the front of the arm and of the forearm, the latter being previously well supinated, so that the upper and the lower portion of the limb may be in the same plane. A little cotton being now interposed between the front of the elbow and the angle of the splint, a second roller should be carried from the hand to the axilla, securing the apparatus to the member. For the first four or five days the dressing should be renewed daily, unless it is found to be comfortable and neither too tight nor too loose, in which case it may be allowed to remain undisturbed for two days. The anodyne lotions in the mean time can be poured over the bandage at the joint.

In cases where the tendency to posterior displacement of the condyles and bones of the forearm cannot be satisfactorily prevented, a trough-shaped posterior angular splint (Figs. 707, 708) may be added to the dressing with an excellent result.

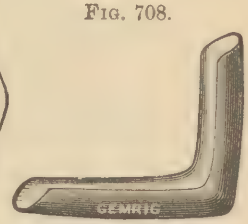
As soon as the inflammation and swelling subside, the surgeon should begin to make passive motion of the joint. This at first can be effected by daily altering the angle of the anterior splint, which can be done without altogether removing the dressing. After the lapse of twelve or fourteen days this motion is best made by removing the apparatus, and, while the posterior part of the elbow rests in the hollow of one hand with the thumb and fingers supporting or pressing together the condyles, the surgeon with the other hand cautiously flexes and extends the forearm. This must be repeated every second or third day, and at the end of the fourth week all dressings should be removed and the limb carried in a sling, the patient practicing daily the lessons which have been witnessed, by executing the various movements of flexion, extension, pronation, and supination, and these should be persevered in, if necessary, for six or seven months. When there is any induration about the extra-articular tissues, systematic rubbing and kneading will materially aid in restoring the normal suppleness of the parts.

Fig. 707.



Obtuse angular trough-shaped felt splint.—Ahl.

Fig. 708.



Rectangular trough-shaped splint.

It is common to meet with cases in which the inflammation from constitutional or local causes has proved uncontrollable and the plastic depositions have become so firm and unyielding as to destroy almost all motion. Of course such a result is not the work of two or three weeks, but of as many months. Under such circumstances a careful examination of the joint must be made in order to ascertain if the rigidity is due simply to fibrinous bands in and about the articulation, or to a more formidable condition, the vicious union of a displaced fragment. If the first, it will be proper to etherize the patient

and forcibly disrupt the adhesions, following this at stated intervals with forced motion. If the latter, the course of the surgeon must lie between re-fracture of the bone and not meddling at all. If the case is a recent one, namely, of eight or ten weeks' standing, and the disability great, let the bone be again broken; if beyond this period, it is better to decline interference. There are cases, again, where the damage is so great that anchylosis cannot be prevented; and then it is the duty of the surgeon to place the arm in such a position as will render it most useful under the circumstances,—namely, at such an angle as will admit of the hand being carried to the mouth.

Compound and Comminuted Fractures of the Elbow-Joint.

In a complex joint like that of the elbow, a compound or a comminuted fracture must be regarded as a very grave injury.

Causes.—These fractures are ordinarily caused by the arm being caught in the machinery of manufacturing establishments, or by its being crushed under the walls or timbers of falling buildings. Not unfrequently the injury is the result of a shot wound. The injury may be confined to one bone of the articulation, or it may extend to all of them. The swelling is usually great, and the succeeding inflammation rapid and very severe.

Prognosis.—After an injury of this kind, even when limited in degree, the prognosis is unfavorable as respects the functional restoration of the joint; and in the more aggravated forms of the accident excision or amputation is the alternative.

Treatment.—If there is fracture either of the olecranon or of the condyles of the humerus, with an external wound, and without much damage to the soft parts, the arm should be placed in a rectangular position and laid upon an internal angular splint, to which it should be loosely secured by a roller, and kept constantly irrigated with water containing a little laudanum. Should this not prove sufficient to control inflammatory action, leeches may be applied about the joint, and the irrigation continued. Pain must be subdued, if severe, by opiates; and as soon as the acute symptoms are entirely mastered, motion must be established, with a view to the future usefulness of the joint. The antiphlogistic applications are to be made for a period of twelve or fifteen days, after which, unless the inflammation remains active, they accomplish little if any good. When it is found that the joint continues to grow more and more rigid, in spite of the movements which have been made, it should be placed at a right angle, the position in which, as an anchylosed articulation, it will be most useful.

In other instances, the bones may be extensively comminuted and yet the vessels remain uninjured and the superincumbent tissues little damaged. The course to be adopted under such circumstances will be the excision of the damaged bone or bones, the subsequent treatment being conducted in the rectangular position, with the water dressing. After eighteen or twenty days, motion may be commenced, in order to prevent anchylosis. If, however, in addition to the comminution of the bones, the soft parts are much mutilated or bruised, and the brachial artery torn, amputation will be indicated, and should be promptly executed.

Cases will be met with in which the favorable and unfavorable conditions are so blended that the surgeon may be undecided what course to adopt. In such an event we are to lean to the side of conservatism, as this does not prevent a resort to an operation should it be demanded at a future day,—that is, after suppuration has been established and the system has recovered from the perturbing effects of traumatic fever.

Fractures of the Bones of the Forearm.

The bones of the forearm are very often the seat of fracture. The exposed position of this part of the upper extremity in the innumerable acts of prehension—offensive and defensive—in which these bones are concerned, explains

the frequency of the accident. Both may be broken simultaneously, though the radius is most frequently affected, a result which might be anticipated from its direct articulation with the hand. The great frequency of fractures of the bones of the forearm will appear from a review of the records of any general hospital. The tables of Flower and of Hulke of the Middlesex Hospital, covering a period of sixteen years, furnish 107 cases of fracture of the ulna, excluding the olecranon (or 183, including such), 768 fractures of the radius, and 191 of both radius and ulna.*

The frequency of these fractures and their relative proportion may be learned from the statement of Malgaigne,† that they constitute one-eighth of the entire number treated at the Hôtel-Dieu.

Lonsdale says that of the 1901 fractures treated in the Middlesex Hospital,‡ covering a period of six years, 386 were of the forearm; and of these, 197 were of the radius alone. From the same tables it is ascertained that fractures of the radius are very much the most common; next, fractures of both bones; and last, of the ulna.

Of the 1802 fractures of the forearm recorded in the Pennsylvania Hospital, 985 were in the radius, 218 in the ulna, and 599 in both radius and ulna. Those of the radius formed 11.4 per cent. of all fractures admitted into the institution. (See Table.)

These fractures are not peculiar to any period of life. We meet with them in young children; but their frequency increases as life advances. This remark applies more particularly to the radius, as the ulna alone is not often broken before mature age.

As to the influence of sex, there is a contrariety of opinion. Malgaigne asserts that in fractures of the ulna four-fifths occur in males, while in the tables of Flower and Hulke, to which allusion has been made, the females exceed the males one-half. Again, the first author gives, in fractures of the forearm and radius, the proportions respectively of 67 to 40 and 95 to 65, or three-fifths in favor of males, whilst the same tables record for the same bones 373 males against 395 females, and, where both bones have been broken, 127 males against 64 females. This discrepancy can, I think, be explained on social grounds.

Fractures of the ulna occur with equal frequency in summer and winter, but the radius is much oftener broken during the latter months, especially near the lower extremity, the majority of the patients being women beyond mature life.

Of 648 cases of fracture of the radius gleaned from the records of the Pennsylvania Hospital, 24 were situated in the upper third, 53 in the middle third, and 571 in the lower third, 186 of the latter being at the lower end of the bone. In 542 instances the side was mentioned, 278 being on the right and 264 on the left side; and in 777 recorded cases of the same injury, 477 occurred in males and 300 in females. Of this same number of fractures, 733 were simple, 21 compound, 10 compound comminuted, 6 simple comminuted, and 7 not determined. The largest number for any decade—153—occurred between the ages of ten and twenty, and the next largest—150—between thirty and forty years of age.

Cause.—This is usually from force applied either directly or indirectly,—the former, when a blow or violence of any kind is applied across the forearm; and the latter, when the patient falls upon the hand and the force is transmitted through the wrist. Malgaigne reports a case of fracture of both bones from muscular effort alone.§

Fracture of both Radius and Ulna, or Fracture of the Forearm.

Fracture of both bones of the arm may take place at any point between their extremities, but is met with most frequently below the middle of the

* Holmes's System of Surgery, vol. ii. p. 764.
† Fractures, etc., Packard's trans., p. 470.
‡ Cooper's Surgical Dictionary, p. 724.
§ Fractures and Dislocations, p. 471.

arm, or where the muscles terminate in the tendons, and where the protection of the fleshy masses which cover the upper portion of the arm is lacking. The bones at the lower half, especially the ulna, are least able to resist violence.

Fractures at the lower extremities, or near the radio-carpal joint, are not at all common. In young subjects they may pass through the epiphysis.

CAUSES.—These fractures are occasioned by force, either direct or indirect. A blow across the arm, the passage of a wagon-wheel, and falls upon the hand, are among the most common causes. The manner in which the force is applied determines the location of the fracture. For example, if it is received directly, the bones will be broken at or near the same level; but if indirectly, as where the hand is put out and the weight of the body received upon it, the fracture will be at different heights, each bone yielding at its weakest point, that of the radius being higher than that of the ulna. Muscular action alone is capable, as in Malgaigne's case, of producing a fracture of the bones of the forearm; but such instances must be exceedingly rare, and due to a diseased state of the osseous tissue.

SYMPTOMS.—Unusual mobility at some point intermediate to the articulating extremities of the bones, pain on motion, crepitus, and perhaps deformity, are the signs of this fracture. Swelling and discoloration may not appear until some time after the accident. Deformity is very often absent, or at least it is so slight as not to be detected through the fleshy parts on a simple inspection of the arm. The limb is entirely disabled, and if it is moved the patient is conscious of both crepitus and pain.

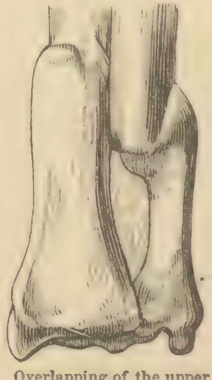
Sometimes we meet with a very marked and persistent deformity in the case of young persons. The arm is curved or bent, no crepitus can be discovered, and the bones will, in spite of the strongest pressure, sometimes remain in this deformed position. This is what is commonly called the "*green stick*" fracture, the separation in the fibres of the bones, under such circumstances, being incomplete or confined to those on the convex surface of the curve.

The *direction* of these fractures of the forearm is always more or less oblique, and the *displacement* may be such as to produce shortening, or angular deformity, anteriorly, posteriorly, or laterally. If the fracture runs upward and towards the interosseous space, the lower fragment or fragments

FIG. 709.

Lower fragments drawn partially between the upper ones.

FIG. 710.



Overlapping of the upper and lower fragments of the two bones of the forearm.

FIG. 711.

Lateral displacement.

may be drawn partially between the upper pieces and wedge them apart (Fig. 709); or, if the direction of the fracture is dissimilar in the two bones, the upper fragment of one bone may pass in front of the lower fragment,

while the reverse may be true of the other bone. (Fig. 710.) When a lateral curve or angularity exists, I have generally seen the concavity of the curve on the ulnar side. (Fig. 711.) Should the fracturing force be applied when the hand is in a state of pronation, the bones may be displaced in opposite directions, the radius backward and the ulna forward. In most cases, however, there is very little overlapping, because the fragments do not entirely become detached from one another, or in consequence of the line of fracture in one bone being so disposed as to resist the displacement of the other; furthermore, the interosseous ligament serves to act as a check to such displacement. Another disarrangement which may occur is the approximation of the two bones, either of the upper or the lower fragments, followed, of course, by a diminution of the interosseous space. This will be produced either by the manner in which the fracturing cause operates—as when the arm is drawn into some machinery edgewise—or by the violent action of the pronator muscles.

In the occasional cases of fracture near to the wrist-joint, the lower fragments are drawn upward and backward, and the injury might be mistaken for a luxation of the carpus. The readiness with which reduction is effected, the reappearance of the deformity when the extending and counter-extending forces are withdrawn, the existence of crepitus, and the fact that both styloid processes move with the lower fragments, are sufficient to distinguish this fracture from a luxation.

Prognosis.—A good cure—that is, freedom from deformity and the restoration of the various movements of the arm—may be anticipated where ordinary attention is bestowed on the dressings. Where the fractures are on the same level, there may be redundant callus deposited, which may impair both pronation and supination: indeed, in many cases of fracture of both bones there appears to remain some defect in full supination. Occasionally non-union is met with in fractures of the bones of the forearm.

Treatment.—The surgeon reduces the fracture by flexing the forearm, in order to relax the muscles which arise from the humerus and are inserted at different portions of the lower arm, and, making extension from the hand while counter-extension is made by an assistant grasping the arm above the elbow, he moulds the parts by pressure into proper position. In many cases there is no displacement, and it is useless to subject the patient to the pain of unnecessary manipulation. The adjustment being perfected, the hand is placed between pronation and supination, the thumb pointing directly upward, and two light splints of poplar or pine wood, well padded, are placed along the anterior and posterior aspects of the limb, extending from the elbow to the tips of the fingers, and one inch wider than the arm. After the extremities of these splints are well guarded, by placing under each some cotton, they are to be bound to the arm by a roller, beginning at the hand and extending up to the elbow, where the bandage may terminate by a few turns about the joint. The arm now, being placed across the breast, is to be supported in a sling extending from the elbow to the fingers. (Fig. 712.)

I see this sling in many instances very carelessly applied, supporting only a portion of the arm: in such cases deformity is liable to follow, particularly if the splints become loose and slip towards the radial side of the arm. This dressing should be removed and re-applied after the lapse of twenty-four hours, as it may become very tight from the swelling: indeed, it should be carefully examined every day for six or seven consecutive days, until the surgeon is quite sure that there is no longer any risk to the circulation.

It is very remarkable that the forearm has most frequently been the subject of gangrene caused by improper fracture dressing; a fact the first notice of which, I believe, has been properly credited to Roux. Hamilton* records several instances of this kind.

I once saw a case in the country, in which the arm became gangrenous

* Fractures, etc., p. 320.

from the injudicious use of a bandage applied for fracture by an intemperate physician, and which required an amputation above the elbow-joint. The liability to mortification, under such circumstances, has been attributed to the superficial position of the radial and ulnar arteries, in consequence of which they are easily compressed by the splints. This is certainly not true of the latter vessel, except near the wrist, and the radial is not more superficial than the brachial. I am disposed to believe that, while pressure on these vessels in the forearm may in part account for so unfortunate a result, the pressure of the upper end of the anterior splint against the brachial artery at the bend of the elbow has often much to do with arresting the circulation. If the forearm is dressed in the extended position, it will be found that when flexed across the breast the end of the anterior splint will press very forcibly against the brachial vessel; and I therefore lay stress on the necessity of applying the splints when the forearm is bent at a right angle with the arm, so that this pressure may be avoided.

Fig. 712.

Fracture dressing for both bones of the forearm.

The dressing of fractures of the forearm cannot be passed over without taking some notice of the opinion of surgeons in regard to matters connected with *position*, *interosseous pressure*, etc.

Ambrose Paré and Lonsdale long since expressed their preference for the supine position in all fractures of the bones of the forearm. Nélaton also, with certain limitations, as when the fracture is in the upper third, inculcated the same doctrine; and Chelius may likewise be said to favor this position. Occasionally we meet with cases in which, in order to insure a proper reduction, this position is demanded; but they are exceptional, and I agree altogether with the great body of American surgeons, in adopting the position of semi-pronation. It is the only one in which the bones are parallel with each other, and which secures the most complete interosseous space. Not only does this position yield the most satisfactory results, but it is also infinitely the most comfortable to the patient.

To amplify the interosseous space, many contrivances have been devised. Of this nature are the convex splints of Amesbury, the concave splints of South, and the graduated compresses of Boyer, all of which are without value. This space is certainly very important to the proper motions of the hand, but it can be secured in another way. A glance at the anterior part of the forearm will show us that the muscular masses which occupy it are convex, so that when the plane surface of a splint is made to press upon them with sufficient power, they are quite sufficient to play the part of a wedge and to thrust the bones apart. Should, however, one of the bones, as the radius, be broken into three pieces, a pad may be applied to prevent the intermediate fragment from striking inward. The enveloping of the forearm with a roller before the application of the splints, when properly done, is not objectionable, but, being liable to great abuse in unskillful hands, it should be discarded from practice. To be of any value in controlling muscular action, the turns of the roller would have to be drawn with a degree of firmness which would endanger the interosseous space.

Fractures of the Radius.

Of fractures of the bones of the forearm, those of the radius are most common. The direct articulation of this bone with the hand exposes it to shocks in various ways, which is a sufficient explanation of the frequency of this accident.

It may be broken at any point, but most commonly at the lower extremity. Hamilton* gives the proportion as to situation in 101 fractures which he had collected to be as follows: in the upper third, 3; in the middle third, 6; and in the lower third, 92. Out of 648 fully recorded cases of fracture of the radius admitted into the Pennsylvania Hospital, 24 were in the upper third, 53 in the middle third, and 571 in the lower third (see table on page 820). While it is true that fractures of the radius are produced commonly by indirect force, as by falls upon the hand, especially those at the lower third of the bone, yet it is often broken by direct force. Packard met with an instance of this injury produced by muscular action alone.

Fracture of the Neck.—There are perhaps not more than one or two cases of such a fracture (verified by post-mortem examination) in existence. One of these is in the Mütter collection, belonging to the College of Physicians of Philadelphia. Many surgeons therefore very properly believe the occurrence of this injury to be of great rarity. Mr. South speaks of it as being common; but Hamilton, with his usual candor, in relating three cases which came under his own observation and which presented all the signs of such a fracture, says that he was not entirely convinced of the truth of the diagnosis. Sir Astley Cooper denied the existence of the fracture, and Malgaigne regards the lesion as exceedingly uncommon. The difficulty which encompasses the subject is the depth of the neck of the radius from the surface, it being buried beneath the fleshy portions of the supinator longus and brevis and the extensor carpi radialis longior and brevior muscles. Many cases which have been accepted as fractures of the neck have, as in Dr. Markoe's case, been most likely forward luxations of the head of the bone.

Symptoms.—The principal sign of this fracture, theoretically at least, would be failure in the head of the bone to follow the rotatory movements of its shaft. To determine this, the thumb should be pressed firmly down upon the head of the bone, just below the external condyle of the humerus, and the hand pronated and supinated. In these motions, if a fracture existed, crepitus would be apt to be detected, as well as acute pain experienced.

Treatment.—When a case of this nature is met with, the arm should be placed in a flexed position, with a view to relax the biceps muscle, which in the extended state would tend both to supinate and to draw the lower fragment forward and upward, by virtue of its attachment near to the tubercle of the bone. The upper short fragment, under the influence of the supinator brevis muscle, would be rotated outward. The hand should be placed in a state of supination, in order that the fragments, in the event of their being separated, may assume their proper relation to each other, and either an anterior or a posterior concave angular splint, well padded, should be applied to the arm and maintained *in situ* by a roller. In most of the cases treated, and where there were good reasons for believing that the fracture had been properly diagnosed, anchylosis followed, with loss of pronation and supination,—the hand being generally pronated,—showing that the radio-humeral articulation had been invaded by inflammation. This anchylosis is to be overcome by force; but the attempt to do so is not to be made earlier than the fifth or sixth week; otherwise, the line of union being yielding, the bone may be made to form an angular prominence anteriorly by the resistance of the tendon of the biceps muscle.

Fracture below the Tubercle.—A fracture in this part of the bone, if above

* Fractures, etc., p. 267.

the insertion of the pronator radii teres, removes the upper fragment entirely from the influence of the pronator muscles, and the lower fragment from the influence of the two supinators, viz., the supinator brevis and the biceps flexor cubiti, the latter being a supinator before it acts as a flexor, especially in the prone state of the hand. The consequence is, the upper fragment is rotated outward and the lower one inward, according to Lonsdale, so that if union should occur under such circumstances the movement of supination would be lost. There can be little doubt that these statements are true within certain limits, and that they should have their weight in the treatment of this fracture. There are specimens in the Mütter collection of the College of Physicians which verify Lonsdale's views, also in the museum of the University of Pennsylvania; and similar specimens exist in the museum of the Royal College of Surgeons, London, as stated by Flower.*

TREATMENT.—The forearm being flexed to a right angle, the hand should be placed in a state of moderate supination, and so retained, either by the anterior or the posterior angular splint, the latter to be preferred, as by it the supination can be more certainly preserved. This will secure to the arm when cured the two important movements of supination and pronation. The usual position of semi-pronation does not fulfill the indications in the treatment of this fracture, and should therefore be abandoned.

Fractures of the Middle Third.—A fracture in this part of the bone is usually the result of violence directly applied, though it may follow a fall upon the hand.

SYMPTOMS.—A fracture in this part of the radius is not difficult of recognition. There will be a loss both of pronation and of supination; the upper end of the radius, when the hand is rotated, will remain fixed; pain, crepitus, and preternatural mobility, with, usually, considerable swelling, will also be present.

The displacement which the fragments may undergo, independent of that resulting from the force, will be, if the fracture is below the insertion of the pronator teres muscle, the tilting forward of the upper fragment by the action of the biceps muscle, and its internal rotation by the pronator teres. The lower fragment will be drawn towards the ulna by the conjoined action of the pronator quadratus and the supinator radii longus. (Fig. 713.)

FIG. 713.

Fracture at the middle of the radius, with the displacement caused by—1, biceps flexor cubiti; 2, supinator radii longus; 3, pronator radii teres; 4, pronator quadratus.—Hines.

It is possible for the upper so to entangle the lower fragment as to carry the latter from the ulna. Overlapping of the fragments cannot occur unless there is a luxation of the ulna, the latter performing the office of a splint for the radius.

PROGNOSIS.—Though this is generally favorable, yet we often encounter among collections of fractures specimens where there is not only deformity, but also such an obliteration of the interosseous space by the irregularities of the callus as must have destroyed pronation and supination of the hand.

TREATMENT.—The arm must be flexed, which at once neutralizes the displacing power of the biceps, and in a less degree that of the pronator radii teres muscle. This, with pressure on the lower end of the upper fragment, will serve to reduce it to the proper position. By insinuating the fingers into the interosseous space, and by strongly abducting the hand, so as to make tense the external radio-carpal ligament, the upper end of the lower fragment can be pressed out. The hand should be placed at semi-pronation,

* Holmes's System of Surgery, vol. ii. p. 793.

and a narrow compress three inches in length fixed over both the anterior and the posterior aspect of the arm, the upper ends of which should stop a little short of the fracture, so as not to affect the upper fragment, the tendency of which is to separate from, not to approach, the ulna. Two splints wider than the arm, well padded, and long enough to extend from the bend of the arm to the tips of the fingers, are to be applied along its anterior and posterior surfaces, leaving out the thumb, and secured in place by a roller, after which the arm should be supported in a sling, across the breast. This dressing, excluding the compresses, is the same as that described for fractures of both bones of the forearm. If the patient proves to be restless, disobeying the instructions to keep the arm flexed, and the fragments become disarranged, it will be necessary to place an anterior rectangular splint upon the anterior part of the arm and forearm, and a straight posterior splint upon its back extending from the elbow to the ends of the fingers, binding them fast with a roller.

Or it may be found that unless the hand is kept adducted—that is, strongly carried towards the ulnar side—the upper end of the lower fragment sinks in and leaves a depression, or encroaches upon the interosseous space. In such a case we should substitute the two straight splints by two pistol-shaped or Nélaton splints. (See Fig. 724.) These will serve to supply the anterior and posterior pressure, and also to maintain the hand in the abducted state. Five weeks will generally prove sufficient to effect a cure, after the lapse of which time the splints may be thrown aside and the arm carried for two weeks longer in a sling.

Fractures at the Lower End.—These injuries, but little understood by the ancients, have been very carefully studied by modern surgeons, among whom may be named Poteau,* Sir Astley Cooper, Desault,† Dupuytren,‡ Diday,§ Malgaigne,‖ Voillemier,¶ and especially Dr. John Rhea Barton,** Colles,†† and Robert Smith‡‡ of Dublin.

These fractures are exceedingly common, and are met with at all seasons, though most frequently during the winter months. Although not impossible at any period of life, they belong more especially to mature and advanced age. After the age of thirty, women furnish the largest number of cases.

Causes.—While fractures of this nature may follow direct force, yet in the vast proportion of cases the violence which breaks the bone is indirect, and is transmitted through the carpus by falls upon the palm of the hand. That the bone should yield at its most voluminous point is probably due to the great preponderance at this part of cancellated tissue, which is inclosed by the thinnest possible film of compact matter, and also in consequence of the presence of fatty degeneration,—a condition very common in women after the middle period of life. The lower epiphysis of the bone does not unite with the shaft until the twentieth year, and when the line of fracture is transverse and near the articulating extremity, it may follow this conjunction.

I have for some time taught that the mechanism of these fractures consists in the manner in which the force is communicated to the bone;—that if the weight of the body is received on the metacarpo-phalangeal portion of the hand, the fracture will be a transverse one, in consequence of the resistance offered by the anterior radio-carpal ligament to extreme extension. To verify the accuracy of this statement, it is only necessary to make the experiment on the cadaver. If the entire hand is violently forced back upon the arm,

* Œuvres posthumes, 1783, book ii. p. 251.
† Œuvres chirurgicales, 1813, t. ii. p. 251.
‡ Leçons orales, 1834, book iv. p. 161.
§ Archives Générales de Médecine, 1837, book iii. p. 141.
‖ Medical Gazette, 1832, p. 730.
¶ Archives Générales de Médecine, 1842, book xiii. p. 261.
** Medical Examiner, 1838, vol. i.
†† Edinburgh Medical and Surgical Journal, April, 1814.
‡‡ Fractures in the Vicinity of Joints.

the radius will give way above its lower articulating extremity; and if the subject is an old one, it requires no very unusual force to produce the fracture. The carpus, under such circumstances, acts as a fulcrum in the mechanism of the lesion. If, however, the weight of the body is received on the heel of the hand, the forcible propulsion of the carpus against the articulating surface of the radius will tend to rive the latter into two or more fragments, causing a comminuted fracture.

Another element in these fractures is stated by M. Bouchet* to be extreme flexion of the hand. This was suggested by his attempts on the cadaver to produce luxation of the wrist-joint. In all his experiments the radius gave way at its lower extremity. Malgaigne records a case examined by Voillemier, which gives additional force to this statement,—where, in a struggle, a man had forced his antagonist's hand into a state of undue extension, and thereby produced a fracture of the end of the bone.

It occasionally happens that, in addition to the fracture of the radius, the styloid process of the ulna is broken. The triangular interarticular cartilage may likewise be disarranged, and the external lateral ligaments be torn. Voillemier† claims that these fractures are in most cases impacted, the upper fragment being propelled into the lower. Mr. Callender‡ entertains a similar opinion; and to these names might be added those of Nélaton, Malgaigne, and Erichsen. R. W. Smith denies that they are impacted, except perhaps where the ulna and the radio-carpal ligaments are broken. I have seen a number of specimens in which impaction existed, but I do not believe this condition is a common one. Where the deformity is persistent, and in the absence of crepitus, impaction no doubt will be found to exist.

According as the theory of impaction obtains will there be less prominence attributed to the muscles as the cause of deformity. Bryant§ says that the thirty-six specimens of fracture of the lower end of the radius in the museums of the London schools prove that the deformity in each case was due to impaction.

The *location* of these fractures is often imperfectly understood. There is certainly much discrepancy among authors as to their seat. Dupuytren placed the fracture from three lines to one inch from the articulating surface; Sir Astley Cooper fixed it, in most cases, about one inch above the styloid process; Nélaton locates it half an inch above the anterior edge of the articulating surface of the bone; Colles places it one inch and a half above the carpal surface of the bone; and Robert Smith has never seen it higher than one inch, and often within one-quarter of an inch, of the articulating surface.

There are several different fractures at the carpal extremity of the radius which will explain the diversity of opinion about the seat of these injuries. The first and by far the most common one is a transverse fracture, which may cross the bone at any point from the insertion of the radio-carpal ligaments to one inch and a quarter above this line. (Fig. 714.) This injury is sometimes accompanied by a fracture of the styloid process of the ulna. (Fig. 715.) The second form is one in which the fracture passes obliquely through the styloid process of the radius, consequently traversing the outer part of its articulating surface. (Fig. 716.) A third form is one in which the bone is comminuted, the lines of separation running both transversely and vertically (Figs. 717, 718), and the vertical one commencing generally at the linear eminence seen on the articulating surface of the bone which separates the scaphoid from the semilunar part of the joint. A fourth variety consists of a transverse fracture, with a detachment of the posterior lip of the carpal articulating surface of the bone. In the collection of Professor John Neill there is a very characteristic specimen of this injury. Last, and perhaps

* Thèse sur les Luxations du Poignet, Paris, July, 1834.
† Archives Générales de Médecine, 1842, vol. xiii. p. 261.
‡ St. Bartholomew's Hospital Reports, 1865.
§ Surgery, p. 850.

rarest of all, is the fracture which breaks off the posterior lip of the articulating surface of the radius (Fig. 719), commonly known as Barton's* fracture. This lesion is exceedingly rare. It is not probable that Dr. Barton himself ever saw a dissection of the injury which he described. Only two or three specimens of the fracture can be found in the different collections of bones in Philadelphia.

Dr. R. W. Smith describes a fracture of the radius in which the carpal fragment is driven forward, and which is produced by a fall on the dorsal surface of the hand. No such injury has, I believe, ever been verified by dissection, and if it does really exist it would probably be found to consist in a breaking away of the anterior lip of the carpal surface of the bone.

FIG. 714.

Transverse fracture of the articulating extremity of the radius.

FIG. 715.

Transverse fracture of the lower end of the radius and of the styloid process of the ulna.

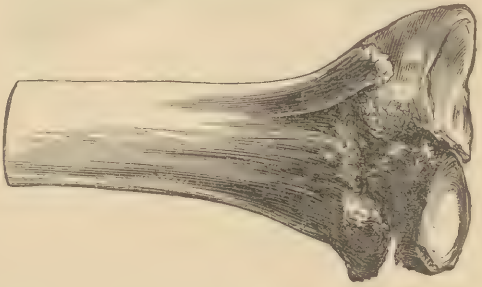
FIG. 716.

Fracture of the styloid process of the radius.

FIG. 717.

Comminuted fracture of the carpal extremity of the radius.—H. H. Smith.

FIG. 718.



Comminuted fracture of the radius.

FIG. 719.

Fracture described by Barton.—From a specimen in Dr. Neill's collection.

SYMPTOMS.—All these varieties of fracture have a general resemblance,—

* Medical Examiner, November 7, 1838.

in the existence of pain, disability, loss of function, rapid swelling, and a peculiar distortion of the wrist. A prominence is seen on the back of the arm, due to the lower fragment being carried upward and backward, chiefly by the momentum of the fall, but partly by the extensor muscles of the carpus and of the fingers. A prominence also exists on the front of the arm, though not so well marked as the one situated posteriorly. This projection is formed by the lower end of the upper fragment. There is also a peculiar inclination of the hand to the radial side of the arm, accompanied by a corresponding prominence of the styloid process of the ulna, induced by the conjoined action of the extensor muscles of the thumb and of the carpus.

If the thumb of one hand is placed firmly upon the head of the radius, and the injured hand at the same time is pronated and supinated, the break in the continuity of the bone may be recognized by the sensation of crepitus and by the immobility of the upper fragment. The exception to this would be in cases of impaction. The swelling, although around the entire articulation, is found chiefly on its anterior aspect, and is due to inflammatory effusion into the great carpal bursa. On the back of the wrist this swelling depends on a similar condition of the sheaths of the six extensor tendons, which occupy the grooves on the posterior surface of the radius. The radio-carpal joint, as well as the surrounding connective tissue, participates in the inflammatory swelling.

There is, however, an appreciable difference in the deformity resulting from these various fractures. When the articulating end of the radius is broken transversely, the posterior prominence formed by the lower fragment is quite large, and the abduction of the hand moderate. (Fig. 720.) If the internal lateral ligament is torn, or the styloid process of the ulna broken, in addition to the fracture of the radius, the abduction of the hand will be much increased.

Fig. 720.

Deformity in an extra-articular transverse fracture of the lower end of the radius,—silver-fork deformity of Velpeau.

When the separation occurs obliquely through the styloid process of the radius, the lateral displacement of the hand becomes very marked, the prominence made by the lower fragment is seen to be more external than posterior, and the projection of the lower end of the ulna is very noticeable. (Figs. 721, 722.) The deformity resulting from chipping off the posterior lip of the carpal articulating surface of the radius is not very great: neither the anterior nor the posterior prominence is as well pronounced as in transverse fractures of the bone, nor is the lower fragment displaced to the same extent upward as in the last-named fractures. The hand likewise may deviate but little from the proper line.

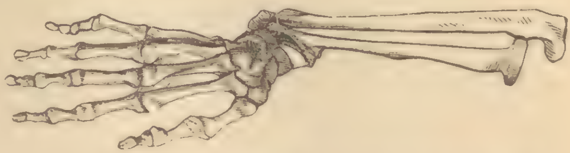
These fractures resemble, in several particulars, dislocation of the carpus. The following considerations will serve to render the diagnosis clear:

First, luxation is a very rare accident, fracture is a common one; *second*, in luxations which resemble these fractures—viz., those which are anterior or posterior—the hand is either flexed or extended, in fracture its inclination is generally lateral and to the radial side; *third*, in luxation there is no crepitus, in fracture it can be usually recognized; and, *fourth*, the deformity which disappears by extension, counter-extension, and pressure will not reappear when this force is removed, if the case is one of luxation, but will immediately return if it is a case of fracture.

Prognosis.—The prognosis after a fracture at the lower end of the radius should be given with considerable reserve, and the surgeon should never neglect to prepare the mind of his patient for some degree of disability, such as stiffness of the wrist-joint, rigidity of the fingers, and some irregularity in

the contour of the parts. Hamilton* says, in speaking on this subject, that of 92 cases of fracture of this part of the radius, only 26 were known to have left no stiffness or deformity about the joint. Indeed, there are many cases where, in consequence of comminution or impaction, rigidity and deformity are unavoidable, and no amount of surgical skill can prevent their occurrence.

Fig. 721.



Fracture of the styloid process of the radius and of the ulna, with great abduction of the hand.

Fig. 722.

Deformity after fracture of the styloid process of the radius.

Treatment.—However fractures at the lower end of the radius may differ in their position, they can all be treated very much after the same manner. The dressings consist of two light well-padded splints, a little wider than the arm, and long enough to reach from the elbow to the tips of the fingers; two graduated or wedge-shaped compresses, three inches long and two inches wide; and two rollers, each two and a half inches wide and five yards long.

Reduction.—Flexing the arm, and taking the hand of the injured member of the patient in his own, the surgeon makes extension, while at the same time, with the thumb of the other hand planted behind the prominence on the back of the wrist, and the fingers placed in front of the arm, he presses the lower fragment into place. Generally by this procedure the deformity disappears. In cases of comminution with impaction, these measures may not succeed in effecting the reduction, in which event others must be adopted; among the most successful of which is the forcible flexion of the carpus while counter-pressure is made in front of the arm.

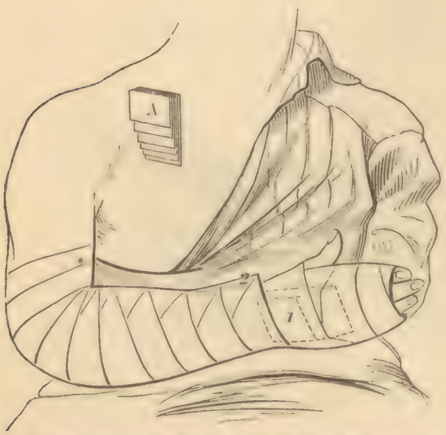
Professor Moore, of Rochester, New York, describes as one of the obstacles to reduction, in one variety of these fractures, the laceration of the internal lateral ligament and the detachment of the triangular interarticular cartilage, in consequence of which the head of the ulna becomes dislocated and the styloid process imprisoned beneath the annular ligament. This being the case, no reduction of the radius can take place until the ulna is released. To accomplish this he directs that the hand be extended and carried at the same time to the radial side, then to the ulnar side, still in the state of extension, and lastly forward or to the position of flexion. During these procedures, which in their entirety may be called circumduction, the wrist is to be maintained in a firm fixed position by the surgeon. If the effort proves successful, the head of the ulna takes its place on the radial side of the tendon of the extensor carpi ulnaris. Cases will occur in which the impaction cannot be overcome, and which, after exhausting the resources at our command for disengaging the fragments, will have to be treated in the best manner consistent with the complication.

After having adjusted the fragments, and while extension and counter-extension are kept up, one of the two wedge-shaped pads is placed on the back of the wrist, with its base above resting upon the lower fragment and its apex directed downward, and the other reversed in front of the arm, its base

* Fractures, etc., p. 281.

lying under the lower end of the upper fragment and its apex directed upward. These two compresses being next bound to the arm, moderately tightly, by a few turns of a roller carried around the hand and the wrist, one of the splints is next placed along the anterior part of the arm and secured in position by the remaining part of the roller. This secures the advantage which has already been obtained by the extension. The posterior splint is now laid upon the back of the arm, and fastened by the second roller, observing to leave the thumb free. (Fig. 723.) This is the dressing of Barton, and very satisfactorily fulfills the object in view. The only caution necessary to be exercised in applying this apparatus is not to bind the graduated compresses too firmly to the arm; indeed, every part of the first dressing should be made a little loose, in anticipation of the swelling which will follow, and when practicable the surgeon should make a second visit to his patient on the day of the accident, to slacken the bandages should they have become too tight. Under no circumstances will it be proper to allow more than twenty-four hours to elapse before the dressing has been subjected to a careful inspection; and for five or six days after the injury the patient should be seen daily. These are not needless precautions. Dupuytren, Hamilton, Norris, and others record cases of mortification and subsequent amputation from a neglect of these precepts. If there is no interruption to the circulation, and the arm remains comfortable, there will be no necessity to disturb the apparatus for the first three days, after which it should be removed and re-applied, extension and counter-extension being steadily maintained while this is being done. From this time forward, or until the fracture is firmly united, requiring usually about five weeks, the dressing should be renewed every third day.

Fig. 723.



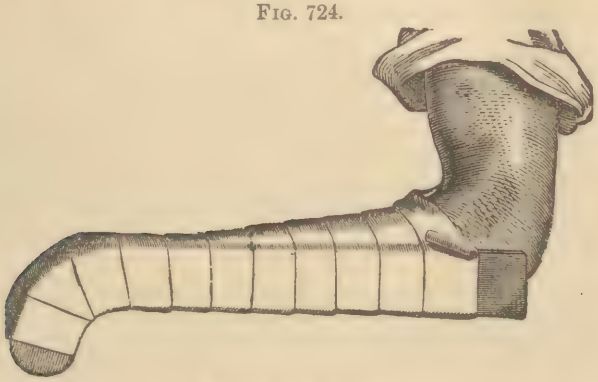
Dressing for fractures at the lower end of the radius, with the wedge-shaped pads.—Smith.

After the lapse of ten days the attention of the surgeon must be directed to the work of restoring the various movements of the hand and wrist.

The stiffness which follows this fracture is due to inflammatory deposits into and between the sheaths of the tendons, as well as within the radio-carpal joint. Gentle movements of the wrist should therefore be commenced as early as the seventh day, at the same time supporting the fracture between the thumb and fingers in order to give security to the union, and increasing these movements from time to time, say every three days, as the consolidation becomes stronger. There need be no apprehension of producing a false joint by this early motion. I am not aware of the existence of any case of non-union of this fracture. The fingers should likewise be manipulated, and, although the patient will experience no small amount of pain, the treatment must be insisted upon, as being necessary to the usefulness of the hand. As there is always more or less thickening about the articulation, from the deposition of lymph, it will be proper, after the second or third week, to bathe the parts at each dressing with a stimulating liniment, such as the linimentum saponis. At the expiration of four and a half or five weeks the dressing may be removed, when the forearm covered with a roller can be carried in a sling. At this time the arm will tolerate more active interference. It may be soaked in hot soap-and-water, the indurated parts well kneaded and rubbed, and the motions made more energetically. The patient must be instructed

and urged to use the fingers and hand by grasping objects, and training the various articulations in their natural actions, until, approximately at least, the original suppleness has been regained. Now, while I believe the plan of treatment just described to be the very best, yet it is proper to say that there are other appliances which have received the sanction of many eminent names. Colles preferred a dressing like that of Barton. Kline, Bransby Cooper, and South employed two splints which extended only to the hand. Nélaton and other Continental surgeons, as well as many in Great Britain and in this country, prefer the pistol-shaped splint. This splint should extend from one inch below the elbow to the metacarpo-phalangeal articulations, and may be applied to either the anterior or the posterior surface of the arm. Nélaton adopted the latter. A short splint must be used in conjunction with this pistol-shaped one, extending from the elbow to the wrist. Both are to be well and smoothly padded, the long one having the padding so distributed as to fill all the inequalities of the arm. After adjusting the fracture, the arm must be flexed with the hand at semi-pronation, and the pistol-shaped or long splint placed along the posterior surface of the arm, with a thin compress interposed over the seat of fracture; next the short splint is laid upon the anterior surface of the arm, and then both are secured by a roller, leaving the thumb free. The arm is now to be placed across the breast and supported in the usual sling. (Fig. 724.)

Fig. 724.



Nélaton splint applied.

Hamilton is partial to a dressing somewhat like that of Nélaton, consisting of one long and one short splint, the former reaching along the anterior surface of the arm from the elbow to the metacarpo-phalangeal articulations, the part designed for the support of the hand being placed at a considerable angle with the rest of the splint. The short splint extends only to the wrist. Both are to be carefully padded, the padding of the long splint being thickest a little above where the lower end of the upper fragment of the fracture is to rest.

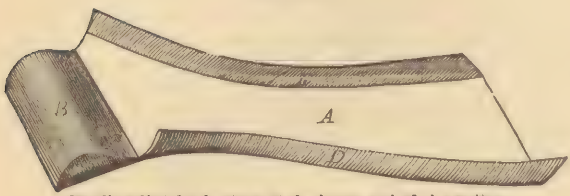
In Philadelphia, the most popular splint for the treatment of fractures at the lower end of the radius is that of Bond. The originator of this splint was evidently guided in its construction by sound anatomical considerations. There are certain postures of the hand which are natural and which are always assumed when the parts are left unrestrained. These positions are moderate flexion of the fingers, and extension of the carpus upon the arm. The first is due to the preponderance of the flexors over the extensors of the fingers; the second, to an excess in power of the extensors over the flexors of the carpus. The abnormal position assumed by the hand, especially after fracture of the styloid process of the radius, is, as has been stated, one of abduction. To preserve, therefore, the normal position of the hand and of the carpus, and to correct the displacements, as well as to allow motion of the fingers, Bond had his splint prepared in the following manner. A piece

of light pine or poplar board, extending from one inch below the elbow to the metacarpo-phalangeal articulations, was cut so as to conform to the shape of the forearm (Fig. 725), the lower two inches being at a slight angle with the rest of the board, and had a convex block secured to its upper surface, with a slight concavity at its inner end for the reception of the ball of the thumb. (Fig. 726.) Such a splint, carefully padded, is placed along the anterior surface of the forearm, the palm of the hand resting upon the block, which, in consequence of the latter being placed on the angular part of the splint, is carried from the radial to the ulnar side of the arm, or in a direction opposite to the deformity.

FIG. 725.

Board cut to conform to the outline of the forearm.

FIG. 726.

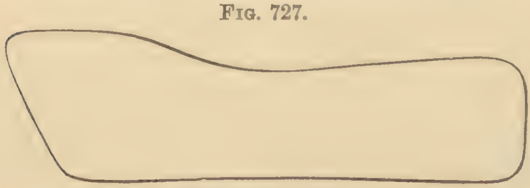


Bond's splint for fracture at the lower end of the radius.

Two wedge-shaped compresses, half an inch thick and three inches long, which can be readily made by recurrent turns of the roller, are next placed on the forearm, the one upon the back and the other upon the front, and so arranged that the apex of the first shall be directed downward, its base resting directly over the seat of the dorsal prominence, and that of the second upward, its base being opposite the lower end of the upper fragment. These compresses, together with the splint, are next secured to the metacarpal part of the hand and to the forearm with a roller, leaving the fingers free.

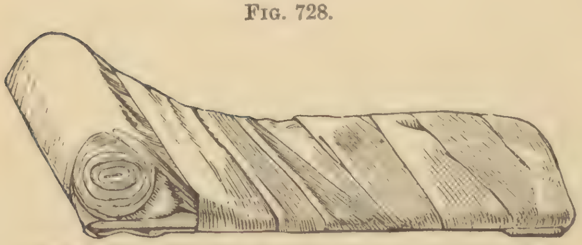
This splint will often answer an admirable purpose where the fracture is not too near the end of the articulating surface of the radius, and where there is little tendency to displacement of the lower fragment; but where it becomes necessary to make extension, it fails to meet the requirements of the case, and is instrumental in producing the very deformity which it is designed to correct.

FIG. 727.



Shape of Hays' splint.

FIG. 728.



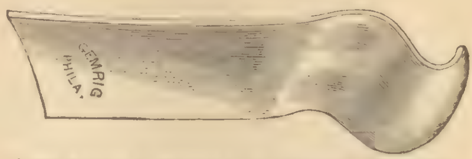
A view of the modified form of Bond's splint as suggested by Hays.

The splint of Dr. Hays may be considered as an extemporized Bond's, and consists of light wood, such as a piece of cigar-box, cut to the shape of the forearm and metacarpal part of the hand (Fig. 727), and having a roller secured transversely at its lower extremity. (Fig. 728.) This splint, after being padded, is applied in the same manner as that of Bond.

Dr. Coover, of Harrisburg, has designed a splint which consists of a single piece, shaped at the lower end in such a manner as to fulfill the indications contemplated both

by the block of Bond and by the anterior graduated compress of Barton. (Fig. 729.)

FIG. 729.



Coover's splint for fracture at the lower end of the radius.

Dr. E. P. Smith employs a trough-shaped splint, with a block which can be moved at pleasure by means of two circular brass plates, and thus the angle of the hand changed at pleasure. This apparatus has the disadvantage of being too complex to be easily constructed. Dr. John Swinburne treats these fractures by placing along the posterior aspect of the arm a straight splint the breadth of the arm, and extending from the elbow to the metacarpo-phalangeal articulations, with two compresses, one at each extremity, the lower one covering the wrist and carpus, and the upper one resting on the space between the splint and the forearm. This apparatus is made fast to the arm by adhesive strips applied at short intervals.

Dr. Gordon, of Belfast, employs two splints, extending to the carpus,—an anterior one, hollowed out, into which the arm is placed in a state of pronation, and a posterior one, broadest at its carpal end, rounded, and placed over the radial surface of the forearm, both being secured by adhesive straps.

Fractures of the Ulna.

Fractures of the ulna may be divided into those of the *shaft* and those of the *processes* of the bone. Of 133 fractures of this bone admitted into the surgical wards of the Pennsylvania Hospital and fully recorded, 52 were through the olecranon process, 3 supposed to be through the coronoid process, 27 in the upper third, 32 in the middle third, and 29 in the lower third; 124 were simple, 34 compound, 10 compound comminuted, and 4 simple comminuted; 74 were on the right side, and 59 on the left side; and of 172 cases recorded, 148 were males and 24 were females.

CAUSES.—These are, in most instances, violence, directly applied, rarely indirectly, as, this bone not being immediately connected with the hand, forces reaching the arm through the latter are realized in a much less degree by the ulna than by the radius.

Fractures of the Shaft of the Ulna.—The inferior portion of the ulna being the smallest, it might be supposed that this would be the part most commonly broken; yet I find that of 88 cases in the table framed from the records of the Pennsylvania Hospital 27 were fractures of the upper third, 32 of the middle third, and 29 of the lower third. It is worthy of notice that these fractures are very frequently complicated. Of 172 cases in the table, 48 were of this nature, a very remarkable contrast when compared with similar injuries of the radius, in which 771 cases furnished but 37 examples of complications. The complications alluded to are compound comminution and simple comminution.

CAUSES.—When the fracture is confined to the ulna alone, it is generally the result of direct force received upon the arm when raised in the attitude of defense, or from falls upon its ulnar side.

DISPLACEMENT.—Theoretically we might expect that the fragments would be drawn towards the radius, thus diminishing the interosseous space, by the action of the pronator teres and pronator quadratus muscles. This is true in many cases, but it is also true that the displacement may be in any direction, being determined by the vulnerating force, independent of muscular action. These fractures are generally oblique, and if the radius remains unbroken there will be little if any overlapping of the fragments.

SYMPTOMS.—Some care is requisite to discover the existence of a fracture of the ulna when, as often happens, there is no displacement. The inner

edge of the bone is easily felt, and the fingers should be carried along its surface to ascertain if there are any irregularities, or any interruption in its continuity. By grasping the ulna above and below the seat of injury and exerting force in opposite directions, mobility and crepitus, when the bone is broken, will be recognized. When, however, displacement is present, the deformity will declare the nature of the injury at once.

Prognosis.—Union usually takes place without much visible deformity. I have seen it, however, fail where there was every reason to believe that the case had been properly treated. Non-union is more common in this bone than in the radius.

Treatment.—The displacement must be corrected by the exercise of such manipulation as will restore the fragments to their proper position. Thus, if they project inward, forward, or backward, pressure should be made directly upon the prominent part, while extension is kept up from the hand. If the fragments fall outward or towards the radius, no effort should be spared to return them to their natural place, as there is great danger, should this not be accomplished, of the loss of pronation and supination. To effect reduction under such circumstances, the hand must be strongly drawn to the radial side, and the soft parts forcibly pressed into the interosseous space.

The fracture being adjusted and the hand placed in a state of semi-pronation, two well-padded splints, in all respects like those for fracture of both ulna and radius, extending from the elbow to the tips of the fingers, with compresses interposed over any salient point which may be present, should be placed along the anterior and posterior surfaces of the forearm, and made fast by a roller extending from the hand to the elbow. The limb should be placed across the chest and suspended in a sling. The change of dressings and other details must be conducted as in other fractures of the bones of the forearm.

Fractures of the Processes of the Ulna.—These fractures embrace those of the olecranon, and of the coronoid and styloid processes.

Fractures of the Olecranon.—This injury, although occurring, according to Malgaigne, only nine times in eleven years at the Hôtel-Dieu, is certainly more frequently met with in American hospitals. In the Pennsylvania Hospital there have been fifty-two cases in thirty-three years. This accident is scarcely ever seen in persons under fifteen or sixteen years of age. The direction of the fracture is generally somewhat oblique (Fig. 730), and may traverse the bone at three points, viz., at the summit, where it joins the shaft, through the base of the process, and through its middle.

Fig. 730.

Oblique fracture through the base of the olecranon process of the ulna.

Causes.—In almost every case it is the result of direct violence, either from blows across the back of the arm or falls upon the point of the elbow. Well-attested cases of fracture from muscular action alone are scarcely to be met with; although I do not deny the possibility of its occurrence.

Symptoms.—These are, usually, well pronounced. After a fall or a blow, there is severe pain experienced at the elbow, followed by swelling and discoloration. The function of the joint is materially impaired; the arm can be only partially extended, or not at all; the prominence of the olecranon changes its normal position, being drawn up by the action of the triceps extensor cubiti, and is no longer in line with the condyles of the humerus. When the arm is flexed, a marked sulcus will be seen behind the joint, into which the fingers can be pressed, which hollow is increased in breadth by flexion of the arm, the process and the shaft being separated from each

other by this position of the arm. The extent to which the detached process will be drawn up varies greatly in different cases. The retraction of the triceps muscle is restricted by the connection of its tendon with the aponeurosis which covers the muscles on the back of the forearm, and hence, when the dense fibrous covering of the olecranon remains unbroken, there will be comparatively little displacement of the bone, although the process may be moved freely laterally when it is grasped between the thumb and fingers. If this fibrous connection, however, be torn, the process will be drawn up to the extent of from half an inch to even two and a half inches. (Fig. 731.) When the fracture involves the summit of the process, there

Fig. 731.

Fracture through the base of the olecranon process, and the detached portion drawn up by the triceps muscle.

should be scarcely any noticeable deformity, as the tendon of the triceps is inserted below the line of separation.

Prognosis.—Fractures of the olecranon are not repaired by the deposition of true callus. Those specimens which are regarded as examples of bony union, were they subjected to the test of maceration for some time, would most probably show that this form of consolidation was only apparent, not real. The two principal causes which operate to defeat bony union are an imperfect apposition of the fragments, and an increase of synovial fluid following the accident, which, by diluting or washing away the reparative material, prevents its organization. An alleged defect in the supply of blood, which has also been enumerated among these causes, does not, in my judgment, explain the result. A fine injection, on the contrary, proves the existence of a very rich supply of blood-vessels over this part of the elbow.

Fig. 732.

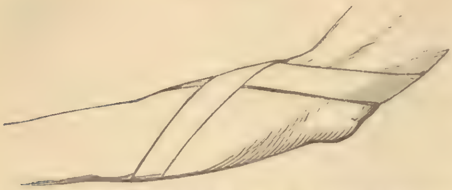
Fracture of the olecranon process, with a ligamentous bond of union which would impair the usefulness of the arm in extension.—Fergusson.

The union being ligamentous, it is important that the fibrous bond should be as short as possible, in order not to detract from the movements of the forearm, especially that of extension. When it is too long, the usefulness of the limb will be somewhat impaired (Fig. 732), though there is a singular difference in different persons in reference to this matter. In the case of a patient who was brought to my clinic with an ununited fracture of the olecranon of four months' standing, the power of extension was in a great measure lost. A few months after, though no union had taken place, the motions of the arm were almost entirely regained. The inflammation which sometimes follows this fracture has resulted in complete anchylosis. Generally the union is sufficiently complete in four or five weeks to admit of a moderate use of the limb.

Treatment.—The arm being extended and the displaced process drawn down so as to be in contact with the shaft of the bone, the middle of a strip of adhesive plaster, one inch and a half broad and eighteen inches long, should be placed immediately above the detached fragment, and the two ends, after being strongly drawn downward and forward, crossed in front of the forearm and finally secured to its posterior surface.

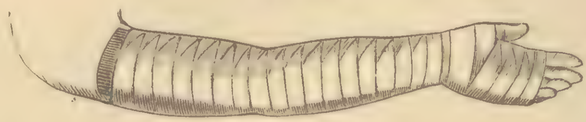
(Fig. 733.) This plaster will hold the olecranon in very good position. A roller two and a half inches wide and six or seven yards in length should next be applied from the hand up to the elbow, encircling the latter by figure-of-eight turns, in such a manner as to give additional security to the apposition, after which it is to be carried up to the shoulder and there terminated, thus controlling the action of the triceps muscle. To maintain the arm in the extended position, a splint, well padded, and having a slight angle, should be placed along the anterior face of the arm, extending from the upper third of the limb to the wrist, and fastened in position by a second roller. (Fig. 734.) This completes the dressing, and commands all the advantages of any other apparatus.

Fig. 733.



Adhesive plaster securing the olecranon process in position.

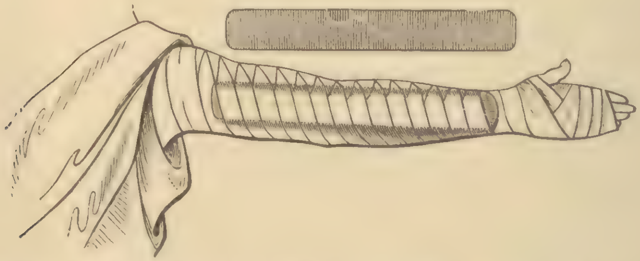
Fig. 734.



Dressing with slight flexion.

With regard to the position of the limb, there are three views. There is, first, the ancient one of semi-flexion, advocated by Hippocrates, Celsus, and others; second, that of extreme extension, which is more especially the practice of English surgeons, and to some extent that of American surgeons, though by neither is it universally insisted upon; lastly, the position of slight flexion. The first, that of semi-flexion, is obviously at variance with all anatomical ideas of adjustment. The second, that of extreme extension (Fig. 735), involves a position exceedingly uncomfortable to the patient, with the additional disadvantage that if the fracture of the olecranon is near to its base there will be a tendency to an anterior displacement of the ulna. The third position, or that of slight flexion, harmonizes with the normal posture of the arm when left unrestrained by muscular contraction, and conduces best to the comfort of the patient and to the proper adjustment of the fragments. This position is preferred by Continental surgeons, and is the one which I have invariably adopted.

Fig. 735.



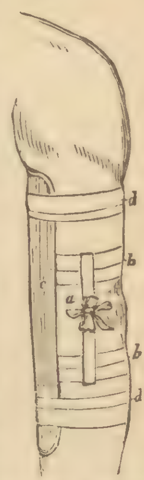
Dressing applied for fracture of the olecranon, the arm being in a state of full extension.

Should there be much contusion of the soft parts, the inflammation severe, and the swelling extensive, no dressing of a permanent nature is admissible until the acute symptoms are past. The arm should be extended upon a

pillow, leeches applied about the articulation, and the parts covered with a lotion of lead-water and laudanum, until the inflammation is controlled. In the course of five or six days an attempt may be made to apply the fracture apparatus, first using only the adhesive strip, and after a day or two more the roller, then finally the anterior splint. Should the joint, in consequence of a compound fracture of the olecranon, or from constitutional influences, or from any local violence whatever, be threatened with anchylosis, the extended position must be abandoned and the flexed one adopted, so that, in case the articulation becomes hopelessly stiff, the arm may still be useful.

To prevent the usual rigidity of the joint, passive movement may be commenced about the fourteenth day, the movements being very slight at first, and the surgeon supporting the fracture with the thumb and fingers when they are made. This period for motion is earlier than that which is generally thought prudent, but I have seen no accident happen to the cure from its adoption, and feel confident that the practice secures a more useful arm than when the manipulation is postponed to a later day. I am satisfied that, so far as stiffness of the elbow-joint is concerned, it is as liable to occur in one position as in the other, and therefore, in this respect, the semi-flexed one has no advantage, with the great disadvantage of offering an insuperable objection to close union of the fragments.

Fig. 736.

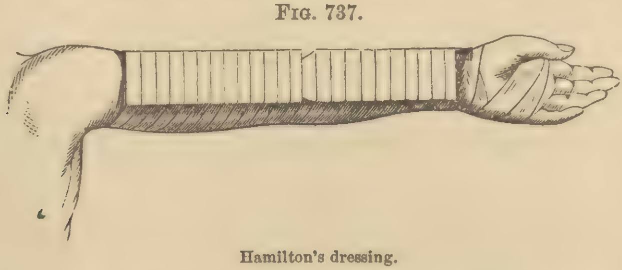


Sir Astley Cooper's dressing.

Other plans have been and are at present employed by surgeons for the treatment of this fracture. The method adopted by Sir Astley Cooper (Fig. 736) consisted in extending the arm, placing two strips of tape parallel with the olecranon, and securing these to the arm by circular turns of a wet roller above and below the joint. The ends of the tape being drawn together and tied served to draw the olecranon towards the shaft of the bone. An anterior splint completed the dressing. There are two objections to this plan, namely, the interference to the circulation from the circular rollers (which, to do any good, must be tight), and the extreme extension of the arm, an uncomfortable position under any circumstances.

Duverney carried a figure-of-eight roller about the elbow, and simply placed the arm, somewhat flexed, on a pillow. The objections to this plan are its insecurity in the case of many patients, and the necessity for confinement during the treatment. Boyer's method consisted in surrounding the arm with a roller, from the hand up to the elbow, but before covering in the latter he folded a long narrow compress, the middle of which was placed above the olecranon, and the two ends drawn down and crossed in front of the arm, after which the roller was passed over this compress and continued up the arm. No splint was placed in front of the elbow. This method is not secure, neither

Fig. 737.



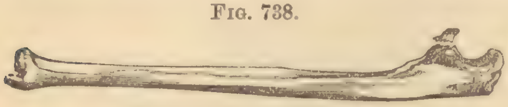
Hamilton's dressing.

does it maintain the fragments in position. Alcock substituted for the compress of Boyer a long strip of adhesive plaster, which was similarly applied. The method of Hamilton (Fig. 737) consists in preparing a splint long

enough to extend from near the shoulder to the wrist, of a width equal to that of the widest part of the arm, and having a notch cut on each side, three inches below the olecranon. This splint is to be well padded, then placed along the anterior part of the arm, and retained in position by a bandage commencing at the hand and extending up to the elbow. When the notches in the splint are reached, the olecranon must be drawn down and the roller conducted upward above the process, and down again to the notch on the opposite side, repeating these turns, each successive one becoming less oblique, and always passing through the notches, until the back of the elbow is covered in, after which the bandage is to be continued up the limb to the shoulder.

Fractures of the Coronoid Process of the Ulna.—Of one hundred and thirty-three fractures of the ulna admitted into the Pennsylvania Hospital, three are noted as fractures of the coronoid process. (Fig. 738.) When it is considered that there are probably not more than four or five cases in existence where the accident has been verified by dissection, the presumption is that not one of these so recorded was really a fracture of this process. I have never witnessed an instance of the injury. The cases which have been established by autopsy, as stated by Hamilton,* are the following: one by Sir Astley Cooper, found in the dissecting-room of St. Thomas's Hospital; one in University College museum, described by Samuel Cooper; one by Velpeau; and one by the late Charles Bell Gibson. Bryant† describes a specimen of this fracture in Guy's Hospital museum, marked 1119^{25}. The cases reported as fractures and collected by Hamilton are twelve in number, to which are to be added five cases reported by Lotzbeck, of Munich, and three by Leis,‡ making in all twenty cases. A case reported by Dr. Duer, of this city, bears the evidence of being really an injury of this kind. There can scarcely be a doubt, therefore, that this fracture does exist, although it is one of extreme rarity.

FIG. 738.



Fracture of the coronoid process.

CAUSES.—Any force, such as a fall upon the hand, driving the process violently against the articulating surface of the humerus, may determine this fracture, and in many of the cases reported the accident is described as having occurred in this manner; but as the radius, in these cases, participated in the injury, its head being displaced anteriorly, it is not improbable that it was mistaken for the coronoid process. In the case cited by Bryant, the head of the radius was also broken. A consideration of the anatomical relations of the coronoid process renders it exceedingly unlikely that this fracture is ever produced by muscular action alone. The brachialis anticus has its insertion on that part of the process where it blends with the shaft of the bone, and therefore cannot exercise any great traction force upon the process itself. The injury is not peculiar to any age, as the cases in which it is said to have occurred varied in age from six years to sixty.

SYMPTOMS.—The recorded symptoms of this fracture are luxation of the bones of the forearm backward, a preternatural prominence of the olecranon, a hard body (the detached process) felt in the front of the arm, and a tendency to luxation whenever the forces employed in reduction are suspended.

PROGNOSIS.—Deprived as the process must be of any considerable number of blood-vessels, it is probable that the union would be fibrous. This was the case in the specimen examined by Sir Astley Cooper.

TREATMENT.—The forearm should be flexed to a right angle, covered by a roller, and a well-padded right-angled splint secured to its anterior surface.

* Fractures, p. 306.

† Surgery, p. 852.

‡ Schmidt's Jahrbücher, 1866, vol. cxxxix. p. 134, Hamilton.

At the expiration of twelve or fourteen days the joint should be carefully moved, and after four or five days more the dressings may be laid aside and the arm carried in a sling. Such a course would seem to be proper in view of the possibility of anchylosis.

Fracture of the Styloid Process of the Ulna.—Fracture of this process may be produced by direct force, as when a blow is inflicted or the patient falls upon this part of the arm. It is sometimes broken at the same time with the lower end of the radius, most probably in consequence of an extreme tension of the internal lateral ligament.

Symptoms.—The signs of the fracture are pain, swelling, and some degree of deformity at the inner part of the wrist. When the hand is carried well to the radial side of the arm, the process may be seen and felt to leave the lower end of the bone.

Prognosis.—These cases are liable to be followed by some deformity; and I think that this is due to the slipping forward of the tendon of the extensor carpi ulnaris, thus preventing an accurate apposition of the broken surfaces. The union in the only case which I have had the opportunity to examine proved to be ligamentous.

Treatment.—The hand and forearm should be placed upon the Bond splint. This splint admits of the hand being carried well to the ulnar side of the arm, which position relaxes the internal lateral ligament and favors the restoration of the process to its proper place. The extension of the carpus will also relax the tendon of the extensor carpi ulnaris. When, by position and by manipulation, the parts are properly adjusted, a compress should be applied over the process, and the splint bound to the arm by a roller carried from the hand up to the elbow, after which the limb may be suspended in the ordinary sling. If satisfied of the correct position of the process, it will not be necessary to disturb the dressing oftener than once in three or four days, unless the wrist-joint or the arm has sustained other injury, when the same precautions against swelling and anchylosis must be observed as are proper in other fractures about the wrist-joint.

Fractures of the Hand.

Fractures of the hand may be divided into those of the *carpus*, of the *metacarpus*, and of the *phalanges*. Simple or uncomplicated fractures of the hand are not common injuries, but they are often associated with such a destruction of the soft parts as to involve the question of amputation. Firearms and machinery constitute the two most fruitful sources of these accidents. The records of the Pennsylvania Hospital from 1850 to 1874 furnish 143 cases of these injuries, distributed as follows: 9 were fractures of the carpus, 53 of the metacarpus, 44 of the phalanges, 17 of the thumb, and 20 not recorded. Of these, 37 were simple fractures, 75 compound, 29 compound comminuted, and 2 simple comminuted. For reasons of a social nature, these fractures are not often met with in females: of the 143 cases to which reference has been made, 137 were in the persons of males, and only 6 in females. The largest number, 50, occurred between the ages of twenty and thirty. Of these 143 cases, 38 demanded amputation, of which number one case died. The causes of death in the cases not operated on were as follows: 2 from tetanus, 1 from pyæmia, 1 from exhaustion, 1 from phlebitis, and 2 from associated injuries.

Fracture of the Carpal Bones.—The carpal bones, being short, irregular, and compactly bound together by powerful ligaments, are rarely the subject of simple fracture, and when it does occur it may be readily overlooked. Cloquet, in his paper on "The Hand," in the "Dictionary of Medicine," gives two cases in which the fractures were only recognized by dissection after death. In the case of a man admitted into the Middlesex Hospital, and who

died from his injuries, a fracture was found passing through the scaphoid bone.* When the injury does occur independent of any serious damage to the soft parts, it is generally produced by falls upon the hand, in which the parts are subjected to severe tension, which, as has been shown by Bouchet in his experiments on the dead body, is capable of breaking these bones.

Symptoms.—In consequence of the swelling and the absence of much displacement, there will be difficulty in detecting the injury, though the existence of pain on pressure, discoloration, and perhaps crepitus when the hand is alternately flexed and extended, may reveal the existence of the fracture.

Fracture of the Metacarpal Bones.—The metacarpal bones are occasionally broken. Of the whole number of fractures admitted into the Pennsylvania Hospital from 1850 to 1874, there were fifty-three fractures of the metacarpus. Malgaigne records only sixteen cases out of the whole number treated in the Hôtel-Dieu.

It is very unusual for more than one bone to be broken at the same time. Of seventy-one metacarpal fractures recorded in the Middlesex Hospital, there were three instances in which two or more bones were broken. There is a discrepancy among authors as to the particular bone most frequently broken. Some, among whom are Chelius and Boyer, think that the fifth is the one most generally involved. Hamilton in his analysis of fourteen cases found the metacarpus of the index finger broken six times, and next in frequency were the fourth and fifth. Berard's observation coincides with this, so far as fracture of the index finger is concerned. In the seventy-eight cases noted in Holmes's Surgery, twenty-seven involved the first metacarpal. I have seen this fracture in all the metacarpal bones except that of the index finger, but most frequently in the fourth. There would seem to be an anatomical reason for a fracture of the third and fifth pieces in preference to the others, in consequence of the prominence of the first and the weakness of the last, in the series of these bones. The situation of the fracture may be in any part of the bone, but the middle and the lower third are the portions oftenest implicated.

Causes.—Except in cases complicated by extensive damage to the soft tissues, these fractures are generally produced by force indirectly applied, as where a blow has been dealt with the clinched fist, in which act the force is received on the phalangeal extremities of the bones. In this way it often occurs with pugilists. Of the fourteen cases collected by Hamilton, eight were produced by violence applied to the knuckles. In three cases of my own it was done in the same way. In isolated cases, a blow may be so concentrated directly on a single metacarpal bone as to cause a fracture. In two instances I have seen this occur. This accident is not peculiar to any age, though uncommon in the young. I have seen a fracture of the metacarpus in a child three years of age, and a similar injury in an old man of eighty-five. It is said that when met with in the young it is probably merely a separation of the epiphysis; but in the instance which I have mentioned this could not have been the case, since the fracture was at the distal end of the metacarpal bone of the thumb.

Displacement and Symptoms.—When the fracture is produced by force applied to the phalangeal extremity of the bones, the displacement is largely due to a change in the position of the anterior fragment, the distal end of which is turned towards the palm, the proximal end forming a projection upon the dorsum of the hand. The carpal fragment, being firmly bound by ligaments, is very much less movable than the other or the phalangeal piece. The deformity described follows from the shape of the bones, which are concave anteriorly; and, secondly, from the influence of the lumbricales and interosseous muscles, the first favoring the sinking inward of the anterior end of the distal piece, and the last producing some shortening or overlapping of the fragments.

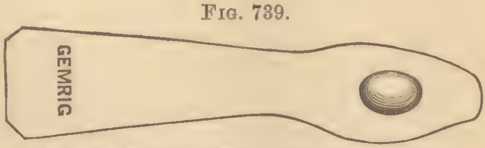
* Holmes's System of Surgery, vol. ii. p. 801.

SYMPTOMS.—The symptoms of this fracture are pain, preternatural mobility, crepitus, sinking or partial disappearance of the corresponding knuckle, and a prominence on the back of the hand. Both the mobility and crepitus are best demonstrated by grasping the proximal phalanx of the injured bone and carrying it forward and backward, while the thumb of the other hand is applied over the supposed seat of fracture.

PROGNOSIS.—When the fracture is uncomplicated, union takes place in three or four weeks: it is not uncommon to have some little prominence on the back of the hand, not, however, impairing its usefulness to any great extent. Occasionally inflammation extends to the surrounding parts, followed by abscess and even anchylosis of the metacarpo-phalangeal and also of the wrist-joints.

TREATMENT.—Except in the case of the metacarpal bone of the thumb, fractures of the carpus and metacarpus are treated on the same general plan. We must observe the concave form of the palm of the hand, and make the splint to conform to its shape. For this purpose a light piece of poplar or pine board, such as that from a cigar-box or a shingle, should be cut corresponding to the outline of the arm and the hand. (Fig. 739.) The palmar portion must be a little wider than the hand, and the splint made long enough to extend from the middle of the forearm to the tips of the fingers. Upon it should be placed some padding, observing to build up a convex elevation with oakum or cotton for the support of the hand. If there is displacement of the broken metacarpal bone, extension should be made from the corresponding finger, and pressure applied directly over the fragments, so as to force them into position. The hand and arm are then laid upon the splint, the form of which admits of the fingers being well flexed. If the ends of the bone incline to become unduly prominent, place upon them a compress, and secure the hand and arm to the splint by the turns of a roller. The forearm should be placed across the chest and suspended in the ordinary sling. The dressing requires to be renewed as often as the state of the parts demands, following very much the same rules in this respect as in fractures of the bones of the arm.

FIG. 739.



Splint for fracture of the carpus and metacarpus.

Sir Astley Cooper describes a fracture through the head (more properly the neck) of a metacarpal bone, which may readily be mistaken for a dislocation. A specimen of this fracture is in my possession. The existence of crepitus and the sinking of both the phalanx and the anterior fragment will serve to distinguish it from luxation. In this injury the dorsal projection is due to the anterior end of the posterior or carpal fragment. In its treatment the hand and arm should be placed upon a splint similar to that for other fractures of the metacarpus, observing to adjust a compress in the palm of the hand, so as to press up the depressed anterior fragment.

When the metacarpal bone of the thumb is broken, it should be treated after the manner of a fractured phalanx, or by having a piece of felt or stout pasteboard wet and neatly moulded to its palmar surface, including also its phalangeal portion.

Fractures of the Phalanges.—The multiform acts of the fingers, their exposure, and their scanty covering of soft parts, render them liable to severe injuries; and hence we often find them not only broken but extensively comminuted. In one hundred and forty-three cases of fracture of the hand admitted into the Pennsylvania Hospital, forty-four were fractures of the phalanges. Commonly one bone is broken, and generally by direct violence, as when the hand is caught under heavy castings or blocks of stone, or in machinery. A case is recorded in which a phalanx was broken by muscular

action while the patient was making a back-handed stroke at another person.* Rarely do we meet with a case of this fracture among females or in very young persons. The serious nature of these injuries is well shown by the statement of Hamilton, "that in a record of thirty such fractures twelve required amputation." We have not a sufficient number of statistics to determine the relative frequency of phalangeal fractures, but, so far as the very limited number recorded enables us to draw any conclusion, it appears that the thumb and the middle and ring fingers are most frequently broken, and that, according to Lonsdale, the first row suffers most from simple fractures.

SYMPTOMS.—Preternatural mobility and crepitus sufficiently indicate the nature of the injury.

DISPLACEMENT.—In most cases of simple fracture the fragments are but slightly if at all displaced; but in exceptional ones there may be a lateral deviation, or, as in a very instructive case related by Hamilton,† a rotation of the phalanx on its axis. If the fracture be very oblique, there may be considerable overlapping.

RESULTS.—In simple fractures good union without noticeable deformity may be confidently anticipated in four weeks.

TREATMENT.—Two methods have been employed in the treatment of these fractures, the semi-flexed and the extended position. The first or French plan, that which was practiced by Ambrose Paré, cannot be regarded as a proper one, though it might in many cases be adopted with great advantage, as when the fracture extends into one of the phalangeal joints and anchylosis is likely to follow, this semi-flexed position being the most useful one for a stiff finger. The second plan is the one most popular with American and with English surgeons. The fragments being adjusted, a piece of pasteboard or felt may be soaked in hot water and moulded to the under and lateral surfaces of the finger, extending a little beyond its extremity. A second splint is required, consisting of a light piece of wood, one inch wide, and sufficiently long to reach from the wrist to one-quarter of an inch in advance of the injured digit. (Fig. 740.) This splint, being well padded, should be placed along the dorsal aspect of the metacarpus and the injured finger, and secured in position either by the turns of a roller three-quarters of an inch wide, beginning at the extremity of the finger and finishing on the metacarpal part of the hand and the wrist, or by spiral turns of adhesive plaster in a similar manner.

FIG. 740.

Splints for fracture of the phalanges.

When two or more phalanges are broken, the entire hand should be placed upon a well-padded palmar splint, as in fractures of the carpus and metacarpus. Thus placed, one finger becomes a support for another, and prevents lateral displacement. It will be necessary to examine the dressing daily for three or four days, modifying the padding and the compression if required by the increase or the subsidence of the swelling.

After five or six days a plaster dressing may be substituted for the splints. For this purpose the roller should not exceed three-quarters of an inch in width, and should have secured between its turns a strip of muslin one inch wide, and long enough to extend from the end of the injured finger, over the back of the hand, to the arm, to which it must be fastened either by a roller or by tearing the upper end into two strips for a short distance, and tying them around the wrist.

Some surgeons, among them Boyer, have advocated amputation for fractures of the last or ungeal phalanx, alleging that the recovery of this delicate piece is very uncertain. I do not concur in this opinion. Two cases of

* British Medical Journal, March 28, 1874, p. 204.

† Fractures, p. 332.

this kind which were under the care of Dr. Koerper, of this city, and one which came under my own observation, recovered perfectly. Other surgeons have had a like success.

Compound Fractures of the Hand.—I cannot dismiss this subject without a word about compound fractures of the hand. When the external wound is limited it does not materially complicate the case, but where there is laceration of the soft parts and comminution of the bones we have to deal with a more serious state of things, often requiring considerable discrimination and judgment in order to determine what course of treatment is best to adopt. Should a phalanx be broken into several pieces and the soft tissues be bruised and torn, in most instances the removal of the finger becomes a necessity. If the metacarpus or the carpus is broken, or even comminuted, with extensive laceration of the soft parts, it is best to pursue a conservative plan, as the hand, being so richly supplied with blood-vessels, possesses a wonderful recuperative power. Under such circumstances any small detached fragments of bone which are present should be removed, and the hand and forearm placed on an anterior splint and kept under the influence of a water irrigation. (See Wounds of the Hand.) By the adoption of this plan many very unpromising cases recover.

Fractures of the Bones of the Pelvis.

Fractures of the pelvis are not very common accidents. Malgaigne states that only ten cases were admitted into the Hôtel-Dieu during eleven years. Ninety-four cases were received into the Pennsylvania Hospital during a period of fifty-four years. In 50 of these cases the fractures were distributed as follows: of the ilium, 33; of the acetabulum, 10; of the pubes, 5; and of the ischium, 2. The largest number, 24, occurred between the ages of twenty and thirty years; 76 were in males, 4 in females, and in 14 the sex was not stated. The number of deaths was 36. Of 65 cases of pelvic fractures collected by Dr. Lyon, 41 recovered and 24 proved fatal. The great strength of the pelvic bones and the resistive power of the ligaments which bind them together necessitate the application of a tremendous force for the production of fracture.

Lodging as the pelvis does a portion of the genito-urinary and digestive organs, and also great blood-vessels and nerves, the violence which fractures one or more of its pieces is liable also to implicate seriously its contents: hence the fatality of these injuries.

Fractures of the pelvis may be single or multiple, and are often conjoined with a dislocation of its bones. When the articular surfaces are thus torn asunder, a layer of bone is usually detached along with the interarticular cartilage. When deeply situated and the fragments are not materially displaced, fracture of the pelvic bones may easily escape detection.

Prognosis.—In all fractures of this part of the skeleton our prognosis should be very guarded. The risks to which the patient is exposed are numerous. He may die from shock; the urethra may be lacerated, or the bladder may be torn, giving rise to urinary infiltration of the perineum or the pelvis, and followed by suppuration and gangrene. The rectum may be wounded, and peritonitis may follow; gangrene of the intestines is not improbable, and sometimes the patient perishes from hemorrhage. Occasionally individuals recover under the most unpromising conditions. In the museum of the Royal College of Surgeons there is a specimen in which the entire pubes has been lost by necrosis as the result of a fracture. The patient was a little girl who entirely recovered from the injury. In the same museum is another pelvis, one side of which was broken in several pieces, and yet all had reunited, the man dying afterwards from fever. Mr. Moore* narrates a case in which repair had taken place where the head of the femur had been

* Medico-Chirurgical Transactions, vol. xxxiv. p. 107.

driven entirely through the floor of the acetabulum and lodged in the pelvis. Bryant* gives the case of a female child, where the damage to the pelvic bones, accompanied with laceration of the perineum, was so great that all the pelvic organs were forced through the lower outlet, and yet recovery took place.

Causes.—Fractures of the pelvic bones are produced by force, both direct and indirect,—most commonly by the wheels of a heavily-loaded wagon passing across the hips, or by the hips being caught between the buffers of cars, or between a wall and the body of a wagon. Falls or kicks upon the trochanter, upon the nates, or on the crest of the ilium, are also methods by which the injury may be produced. Gunshot fractures of these bones are quite common.

Fractures of the Sacrum.—The sacrum, of all the bones of the pelvis, is least exposed to fracture. Its spongy tissue and its curves, its association and ligamentous connection with the innominate bones, all conduce to its protection. It may be broken alone, or its fracture may be conjoined with fracture of the other bones. The lower half is the portion most liable to yield, inasmuch as it is not only the weakest but also the most exposed part, the upper portion being protected by the posterior projection of the innominate bones.

Causes.—The causes are in most instances concentrated and intense force directly applied to the part, as when a person falls from a considerable height, striking upon the lower end of the bone, or upon its dorsum ; or when the wheel of a wagon passes across the back of the pelvis. Indirect violence may also induce such a fracture, but it is then associated with similar injury to the other bones.

The direction of these fractures may be transverse, oblique, or vertical. Most commonly they are transverse.

Displacement.—The displacement, when present, consists in an anterior projection of the lower fragment, due to two causes,—first, the blow, and, secondly, the contraction of the gluteus maximus, coccygeus, and sphincter ani muscles. Lateral distortion is not likely to occur, as the lesser and greater sacro-sciatic ligaments counteract such a change in the position of the fragments.

Symptoms.—There will be pain of a very acute character, which will be intensified by any movements calculated to disturb the fragments, such as flexion or extension of the body, thereby pinching some of the sacral nerves. All straining efforts, as defecation, urination, coughing, or sneezing, produce severe suffering. Posterior angular deformity may be visible, and by introducing a finger into the rectum and pressing upon the coccyx, both crepitus and mobility may be detected. In addition to these symptoms there will probably be present paralysis of the bladder and of the rectum, both of these organs receiving nerves from the sacral plexus.

Prognosis.—A force which is sufficient to fracture the sacrum will generally inflict so much damage upon the pelvic organs that a fatal result may be anticipated. Should the case be one of modified diastasis, as when a layer of the bone underlying the cartilage which connects the sacrum with the ilium is detached, the prognosis is more favorable. Dr. Banks† reports a case of such an injury, the displacement being upward to the extent of one inch, notwithstanding which the patient recovered. Dr. Burlingham, of Illinois, records a very remarkable case in the April number of the American Journal of the Medical Sciences for 1868, of a compound fracture of the sacrum, in which the urine flowed for some time through the wound, yet the patient entirely recovered.

Treatment.—If there is only a slight disarrangement of the fracture, there will be no necessity for any officious attempts to effect a nice apposition. The patient should be placed upon the back, the thighs being flexed

* Surgery, p. 856.

† Atlanta Medical and Surgical Journal, May, 1866.

and supported over pillows. In order to take off all pressure from the sacrum, an ovoidal air-cushion may be placed under the hips, or, when an appliance of this kind is not at hand, a cushion can be made to slip under the pelvis, with an opening cut out corresponding to the sacrum. When the bowels require to be opened, this cushion should be removed, and a rubber bed-pan placed under the nates. The urine must be drawn at intervals of six or eight hours, and if there is any evidence of the bladder being wounded, a gum catheter should be introduced and allowed to remain, so as to keep the organ drained until the damage is repaired. Pain must be alleviated by anodynes, and if inflammation of any portion of the contents of the pelvis arise, it should be counteracted by leeches to the perineum, and by flaxseed or corn-meal poultices laid over the hypogastrium and kept warm and moist by being covered in with oiled silk. If the patient is unable to expel the contents of the bowels, injections of warm water will be required to remove any accumulation; and if, in consequence of paralysis, all retentive power in the bowels is lost, the discharges from the rectum may be received upon a pledget of oakum kept under the nates, while the stillicidium of the urine can be passed into a urinal placed between the thighs. That the fragments may be disturbed as little as possible, it is proper for the first three weeks to keep the bowels closed by opium, for five or six days at a time. Should the displacement be very marked, so as to encroach upon the cavity of the pelvis, reduction may be effected by inserting a finger into the rectum and pressing the parts backward into their proper place. The difficulty, however, will be to maintain the reduction after the finger is removed. Both M. Indes and Bermond employed permanent mechanisms as substitutes for the digit. The first used simply a piece of wood, cylindrical in form, five inches long, and three inches in circumference, which was inserted into the rectum and retained by graduated compresses supported with a T- bandage. He removed this plug or splint every third day, using an injection before its reposition. Bermond, instead of the wooden cylinder, used a silver canula, with a bag attached, which when stuffed formed an inner and an outer tampon, with a cork in the end of the tube to prevent the constant flow of fæces. It was removed only twice during the treatment, once on the seventh day and again twelve days later. Both of these cases recovered. The gum colpeurynter might be used with advantage in a case of this kind, by introducing it into the bowel and then distending it with water or air.

Fractures of the Coccyx.—Until the age when the different pieces of the coccyx are united by bone, an uncomplicated fracture would be one of the most improbable of occurrences. Fractures of this bone are said sometimes to occur during parturition, by the pressure of the fœtal head while engaged at the inferior strait of the pelvis; but such cases are probably often luxation or rupture of the ligaments which unite the articulations. The accident may occur not only from the cause just named, but also from kicks, blows, and, as I have known, from a rider's coming down upon the back of the saddle in an attempt to mount a restive horse.

The displacement in fracture of the coccyx is forward, and is produced by the same agencies as those which cause the deformity in fracture of the sacrum. The damage done to the last spinal nerves in injuries of the coccyx often gives rise to an exceedingly painful state of the soft parts overlying the bone, to which the name of *coccydynia* has been given. Necrosis may follow this injury, either resulting in spontaneous expulsion of the fragment by piecemeal, as in a case mentioned by Cloquet, or necessitating its excision.

Treatment.—Little more is to be done than to enjoin quiet in the recumbent position, placing beneath the nates the oval cushion which I have directed in fractures of the sacrum, in order to relieve the coccyx of all pressure. The position on the side can be occasionally assumed with comfort to the patient. Should the bone project forward, so as to encroach materially upon

the anus or on the pelvic outlet, the finger, well oiled, may be introduced into the bowel, and the bone pressed back into place. If the deformity returns, it may be proper to resort to such tampons as have been described for fractures of the sacrum. Should there be much inflammation present, leeches, followed by a lotion of lead-water and laudanum, will prove of service in diminishing the liability to neuralgia, abscess, fistula, and necrosis. South was able to cure two tedious cases of extreme sensitiveness of the parts following fracture of the coccyx by adjusting to the tuberosities of the ischii two oblong cushions, which removed all pressure from the lower end of the spine when in the sitting position.

When the patient suffers from *coccydynia*, it has been advised by Simpson to introduce a narrow bistoury between the soft parts and the bone and completely sever all connection between the two. This does not always cure the patient, as I very well know; but the harmlessness of the procedure and the occasional success of the operation are sufficient reasons for trying this plan before adopting a more radical one. Should it fail and the symptoms continue severe and persistent, the excision of the bone may become necessary.

Fractures of the Ossa Innominata.

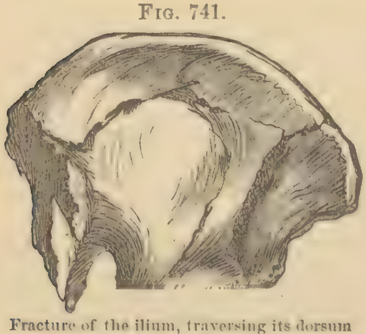
These bones being composed of three portions, the ilium, ischium, and pubes, we may have fracture of either piece singly, or of all three at the same time. Malgaigne describes what he calls "*double vertical fractures*" of the pelvis, as when both branches of the pubic bone are broken and a second line of fracture is situated behind the acetabulum, in the ilium or sacrum, running vertically. The middle fragment will contain the hip-joint, and may be displaced upward or downward, or it may be turned by either its upper or its lower extremity towards the pelvic cavity. He narrates a very interesting case of this injury in a woman, reported by Papavoine in the Journal des Progrès, tome x. p. 234. Both innominate bones may be simultaneously broken.

These fractures are produced generally by direct force, such as falls upon the pelvis, intense pressure by wagon-wheels or between cars, or by falling timbers, gunshot injuries, kicks from horses, etc. Drs. Joy and McWhinne, two Canadian physicians, have recorded a fracture of the anterior superior spinous process of the ilium which they allege was caused by muscular contraction alone.

Fractures of the Ilium.—A large portion of the ilium, namely, the upper expanded part, being at some distance from the pelvic organs, forming a portion of the abdominal wall, and being lined within by the iliacus internus muscle, its fractures are not so dangerous to life as are those of the other bones.

The bone may be severed through the iliac fossa, either transversely or vertically, tearing the iliacus internus muscle (Fig. 741), or it may be broken in a line near to and parallel with the crest, through the anterior superior spinous process, and even through the base of the posterior superior spinous process, as in a case narrated by Hamilton, but which, I believe, stands alone. Malgaigne speaks of these fractures near the crest as taking their start either in front of or behind that remarkable projection situated at the junction of the anterior and middle thirds of the crest, and running thence either forward or backward, or, in some instances, in both directions, constituting a double fracture. In many instances this observation will be found to be quite correct.

Fig. 741.



Fracture of the ilium, traversing its dorsum transversely and vertically.

Symptoms.—There is acute pain experienced on motion. The patient is unable to stand or to walk. If, while

the limb is flexed and the body inclined forward, thus relaxing the muscles and the strong fasciæ attached to the upper border of the bone both within and without the pelvis, the crest of the ilium is grasped and pressed back and forth, mobility and crepitus may be detected. The displacement, in some instances, is so slight that no crepitus whatever can be discovered. In other cases, as when the crest is broken, the detached fragment may be found drawn considerably away from the other part of the bone by the action of the abdominal muscles. When the anterior superior spinous process is broken, it may be displaced downward by the sartorius muscle, and if the line of separation extends some distance back into the crest, the tensor vaginæ femoris will assist in causing the same deformity. Any attempt to turn in bed almost invariably causes pain in pelvic fractures. The contusions incident to these injuries are soon followed by extensive discoloration.

Accompanying these fractures will sometimes be found a rupture of some portion of the abdominal or pelvic viscera. In a case admitted to the University Hospital, the pelvic cavity was partially filled with blood, in consequence of the damage sustained by the iliac veins. Hamilton* records a similar injury.

Treatment.—The patient must be placed upon his back, and the body and lower extremities so disposed as to insure the relaxation of those muscles which tend to produce displacement. To this end the limb should be drawn up, and the body somewhat flexed by raising the head and chest with pillows. When the crest is separated from the body of the bone and drawn up by the broad muscles of the abdomen, the most complete adjustment and relief will be secured by simply inclining the body towards the affected side. Sometimes, however, it will be found that the patient instinctively assumes a position which, although it may be contrary to our anatomical notions of what is the true one, gives complete relief from suffering, in which case it is well not to insist upon enforcing a compliance with any theoretical ideas which may be entertained upon the subject. The position once secured, the pelvis should be surrounded with a strong, broad bandage of drilling, made fast with pins.

If the anterior superior spinous process is detached and displaced, the leg should be flexed on the thigh and the thigh upon the abdomen, in order to admit of the bone being readily reduced, after which an opening should be cut in the bandage to receive and to retain in place the broken fragment. Adhesive strips can be substituted for the broad encircling bandage. After adjusting the fracture, these strips, which should be two inches wide and sixteen inches long, may be carried from the tuber of the ischium, diagonally, upward and forward across the side of the pelvis upon the abdomen, until the bone is entirely covered in. When the anterior process is the seat of the fracture, the first strip must cross immediately in front of this part of the ilium. When the fracture is a compound comminuted one, any loose pieces of bone should be removed, as they are liable to perish, and, acting as foreign bodies, cause troublesome fistulous openings. The condition of the bladder must be attended to, the catheter being used when the patient experiences any difficulty in passing the urine. A bed-pan will be required, in which to receive the alvine evacuations, and when there is much abdominal soreness relief will be obtained from hot fomentations. The callus which unites these fractures, as has been observed by Prof. John Neill, is formed on the outer surface of the bone alone.

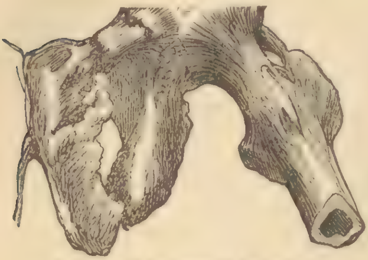
Fractures of the Pubis.—The causes of fracture of the pubis are similar to those producing like injury of the other pelvic bones, and may affect the horizontal ramus, the descending ramus, or the body, and, in some instances, all three simultaneously. It may also be detached from its fellow bone at the symphysis, severing the connecting cartilage and ligaments. (Fig. 742.) The examples of this separation are quite numerous. Lente† has described one

* Fractures, p. 342.

† New York Journal of Medicine, Second Series, vol. iv. p. 286.

caused by severe pressure of the pelvis between two cars; there was also in this instance a wound of the bladder. Malgaigne furnishes four cases produced by forcible abduction of the thighs. He has also collected seventeen cases of disjunction of the bodies of the pelvic bones, from causes connected with parturition. The case of Cappelleti,* recorded as one of fracture from muscular action alone, is vitiated by the fact that the weight of the body falling upon the ground is not considered, and this may have been an important factor in determining the lesion. The rami of the bone are the portions most commonly broken, and the great danger attending the accident is from the liability of the bladder to be wounded by the displaced spicules or splinters of bone. In one-half of the fatal cases analyzed by Lyon, urinary infiltration was the cause of death. Nélaton relates a case at the Hôpital Saint-Louis of a woman who had a fractured pubis, a splinter from which had penetrated both the bladder and the vagina, and which he removed through the latter canal, yet who recovered, notwithstanding both urinary infiltration and abscess followed. This patient was probably the same, says Malgaigne, who in after-years had a calculus removed from her bladder by Lenoir, at La Pitié, the nucleus of which was a fragment of bone. In a case of fracture of the body of the pubis in a female, under the care of Maret, an obstruction was encountered while attempting to introduce a catheter. On making an incision into the labium, this obstruction was found to be the principal part of the body of the pubis: the fragment was removed without difficulty. This patient recovered, and afterwards became the mother of two children. Ruptures of the bladder are not always produced by a fragment of bone: if the organ happens to be distended at the time of the accident, it may be torn by the concussion alone. Whenever the opening, as shown by Sir Astley Cooper, is above the peritoneum, a fatal termination follows from peritonitis, but when it is below this membrane, in the cellular tissue of the pelvis, recovery is possible, though abscesses and sloughing may be anticipated.

FIG. 742.



Fracture of the rami of the pubis.

SYMPTOMS.—Severe pain, aggravated by pressure on the body of the bone, inability to stand or to walk, and a feeling of falling apart, with ecchymosis, constitute the principal phenomena attending this fracture. Sometimes by grasping the tuber of the ischium with one hand and the body of the pubis with the other, and pressing in opposite directions, both crepitus and motion may be felt.

TREATMENT.—Little is usually to be done in the way of reduction, as it is improbable that much displacement will be discovered, save perhaps in cases where the bones are separated at the symphysis. The pelvis may be surrounded with a strong muslin bandage, or with a broad piece of leather having buckles and straps attached by which it can be drawn as tightly as may be desired, and thus press together the disjoined bones. The dressing which I prefer, and which is much more simple and efficient, is a strip of adhesive plaster four inches wide and sufficiently long to extend two-thirds around the pelvis. Over the hypogastrium a piece of muslin must be laid so that the hair covering this region shall not become adherent to the plaster. In the application of the latter, the thighs must be flexed and kept close to each other, so as to relax the adductors, the pectineus, the psoas, and the iliac muscles; the innominate bones must next be pressed strongly together, and the adhesive strip laid on so as to cross anteriorly from one side of the pelvis to the other, its upper margin being a little above the anterior superior spinous processes of the iliac bones. Should the rami of the pubic bone be

* Ranking's Abstract, No. viii. p. 83.

displaced, pressure should be made upon the salient points, and, if the patient is a female, a finger may be passed into the vagina and thus act very effectually in pressing a fragment into place.

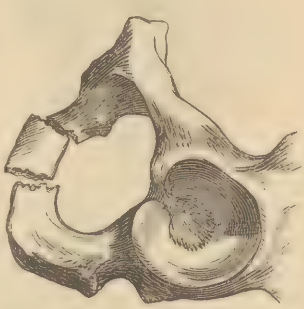
The condition of the bladder must be carefully inquired into, as from this quarter comes the greatest danger. A gum catheter should therefore be immediately passed into the organ and allowed to remain until it has been ascertained that this viscus is uninjured. This should take precedence of everything else. We must not wait until the extravasation takes place before employing the instrument: this is the very mischief which we desire to prevent. Should a rupture in the organ exist, if the urine be kept entirely drained away for seven or eight days we may hope that the rent by this time will be sufficiently repaired to prevent leakage. In the event of subperitoneal or pelvic urinary infiltration being present, the signs of which are pain, swelling, and discoloration (the last two advancing forward and spreading over the perineum and the scrotum, and sometimes accompanied by bloody micturition), free incisions must be made without delay into the scrotum or the perineum. In some instances the urethra has been torn entirely or partially across, near the neck of the bladder, as in the cases of M. Nivet and M. Boudet,* also in one reported by Dr. Clark in the Massachusetts General Hospital.† In such a complication the perineum should be opened and the incisions carried into the bladder as in the operation for stone, in order that the urine may have an unobstructed escape. Inflammation must be combated by leeches and external warmth, and pain controlled by opiates.

Fractures of the Ischium.

Fractures of the ischium, though often conjoined with similar injuries of the pubis, are not so common as those of the other bones of the pelvis. Only twice in fifty recorded cases of pelvic fracture was it met with in the Pennsylvania Hospital. The ischium may be broken in the course of its ascending ramus, or where the latter joins the descending branch of the pubis; also through the tuberosity; and last, near to the acetabulum.

Causes.—In addition to those already described as being productive of pelvic fractures, falls upon the buttocks are to be mentioned. In one case, pressure made during the instrumental delivery of the fœtal head caused the accident. The risk to the urethra and bladder is quite as great in fractures of the ischium as in those of the pubis. In several recorded cases of the injury there existed both an external wound and comminution of the bone.

Fig. 743.



Fracture of the ramus of the ischium.

Symptoms.—After an accident producing fracture of the ischium, there will be inability to stand or to walk, or, at least, great difficulty in attempting either without support. By placing the patient on the breast and grasping the tuberosity of the bone, mobility and crepitus may be recognized. The fracture can sometimes be discovered by a digital examination made through the rectum or through the vagina, even when nothing abnormal can be detected by an external inspection of the parts.

When the fracture is a compound one, a careful exploration should be made by a finger introduced into the wound. The displacement following a detachment of the tuber ischii will be in a downward direction, in consequence of the attachment of the hamstring muscles.

Treatment.—The patient may be placed upon either the back or the side.

* Malgaigne, Fractures and Dislocations, Packard's trans., p. 520.
† Boston Medical and Surgical Journal, vol. liii. p. 646.

If the former position is adopted, the limbs should be moderately flexed over pillows, and, to prevent the tuberosities from pressing against the mattress, an ovoidal air-bag or a ring cushion, one inch thick, should be placed beneath the pelvis, the limbs being then secured together. The catheter must be passed in order to ascertain the condition of the urethra and the bladder, and to remove the urine if there is the slightest ground for supposing that either has sustained injury.

Fractures of the Acetabulum.

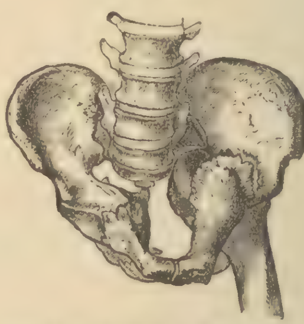
In fifty cases of fractures of the pelvis placed on the records of the Pennsylvania Hospital, ten extended into the acetabulum.

The floor of the cavity may be traversed by a single fissure or by a number of radiating lines of fracture, without displacement; or it may be driven before the head of the femur into the pelvic cavity; or the margin of the cavity may be chipped off; or, lastly, the three pieces which conjoin to form the cotyloid cavity may be separated from one another, an accident most likely to occur in young subjects. The cabinet of Professor Neill contains a specimen of this kind (Fig. 744) in which the union is complete and with very little callus on the articular surface. Moore* has recorded a case in which the head of the femur was driven through the acetabulum into the pelvis. (Fig. 745.) A very remarkable case of this kind was the "Old Piper," known on both sides of the Atlantic,† who died in February, 1839, in the Mercer Hospital, from tubercular disease. Several years before, he had met with a severe injury of the hip, which at the time was regarded as a fracture of the neck of the thigh-bone. This man, after being treated for some time, was able to walk long distances, although somewhat lame. After his death it was found that the old injury consisted in a fracture of the pubis and also of the acetabulum, allowing the head of the femur to pass into the pelvis, where it had remained covered by a shell of bone.

Fig. 744.

Fracture of the acetabulum and of the ramus of the ischium.—From a specimen of Professor Neill's.

Fig. 745.



Travers's case: head of the femur driven into the pelvis.—Bryant.

When the margin of the acetabulum is broken, it permits the head of the femur to slip when the thigh is rotated, producing as a secondary result a luxation, in which case the ligamentum teres may be torn.

Causes.—Fractures of the acetabulum are produced by violence applied upon the side of the pelvis, or, more commonly perhaps, by falls or blows received upon the trochanter or the knees.

Symptoms.—These fractures are very obscure, and are liable to be con-

* American Journal of the Medical Sciences, August, 1839.

† Bryant, Medico-Chirurgical Transactions, vol. xxxiv.

founded with fractures of the neck of the femur, or with dislocation of its head. There are no signs clearly distinctive of this injury. When we carefully analyze the symptoms presented in the cases on record, we find a singular want of uniformity in their phenomena.

In a case of this injury recently under my care, in a very prominent citizen of Philadelphia, there was no shortening, although the most careful measurements were made. Pressure over the body of the pubis caused no pain, and the patient was able to sit up and ride a distance of nearly two miles to his home after the accident. He was able to raise the limb, and to flex the leg upon the thigh, and the thigh upon the abdomen; he could invert and evert the toes; there was no crepitus like that of fracture, and he had entire command over the bladder. The only movement which caused severe pain was the attempt to turn upon the side, and this occasioned violent muscular spasms. When the thigh was flexed upon the pelvis and then rotated, the arc of the circle described was uniform up to a certain point, but beyond that the head of the bone appeared to slip. On the strength of this peculiar symptom a fracture of the lip of the cotyloid cavity was suspected, and the treatment adopted accordingly. A subsequent autopsy not only proved that this was the case, but also revealed a fracture of the floor of the acetabulum, through which the finger could be thrust from the pelvic side.

In distinguishing between fractures of the rim of the acetabulum and those of the cervix of the femur, attention should be given to the following particulars:

First, in fractures of the neck of the thigh-bone (unless impacted) the foot is everted, often lying on its outer side. In the cases of fracture of the rim of the acetabulum the verity of which has been determined by post-mortem examinations, the toes were turned inward, in one case very slightly outward at first, though afterwards changing to the other direction.

Second, in fractures of the neck of the femur the trochanter major should be found appreciably nearer to the crest or to the anterior spinous process of the ilium than in a fracture of the lip of the acetabulum attended with displacement of the thigh-bone, inasmuch as the head of the latter is much more voluminous than its neck, and therefore keeps the trochanter out.

Third, in fractures of the neck of the femur, if the shortening is overcome by extension it will immediately reappear on the removal of the force, in whatever direction the axis of the limb is placed. In fractures of the rim of the acetabulum, if the thigh is drawn to its proper length, and at the same time the head of the bone directed towards the broken side of the cavity, the shortening will occur while the limb is so placed.

Fourth, the crepitus in fractures of the neck should be more rude, rough, or grating than in those of the rim of the acetabulum, since in the first there are two irregular surfaces of bone rubbing together, whereas in the latter the cartilaginous surface of the head of the femur forms a modifying element in the sound elicited by contact with the broken surface. This was very noticeable in a case which I once examined, the sound being exactly like that which is experienced when the surfaces of a relaxed joint are made to play upon each other.

The signs which should distinguish this fracture from a simple dislocation are mainly two. First, in simple luxation there is a definite, generally unvarying, direction of the foot: it is either inverted or everted. Not so in this fracture: the toes may point in any direction. Secondly, in simple luxation the head of the bone once restored so remains, while in fracture it slips again into its abnormal position as soon as the reducing force is withdrawn.

The same uncertainty attends fractures of the floor of the acetabulum. The shortening varies from half an inch to two inches; the foot may be inverted or everted. If, however, the surgeon encounters a case in which, after unusual violence has been applied to the pelvis,—as, for example, over the trochanter,—there follow shortening, acute pain when the joint is moved, crepitus produced by extension and relaxation of the limb rather than by

rotation and flexion, and if in addition the great trochanter is found nearer to the anterior inferior spinous process than that of the sound side, with the foot showing no special tendency to eversion, the presumption is that the case is one of fracture of the floor of the acetabulum. If the patient should be a female, much light might be thrown upon the case by an exploration through the vagina, by which any undue prominence within the pelvis could be detected; and to those practitioners who advocate the introducing of the hand into the rectum for purposes of exploration, a new field for diagnosis is opened, though it might be difficult to say which of the twain, the hand or the head of the bone, would be capable of doing the most damage within the pelvis. In these cases the obturator nerve is liable to injury, and a painful condition of the muscles to which it is distributed would follow. In the case of the "Piper" referred to, considerable pain was experienced; and in Morel Lavellée's patient, recorded by Malgaigne, the severe pain present was supposed to be due to coxalgia.

Treatment.—This should be very much the same as that for fracture of the thigh, namely, a fracture-bed, prepared as for the latter, and extension by means of a weight attached to the limb by adhesive strips. A broad adhesive band drawn across the front of the pelvis, or around it, if the lip of the acetabulum is supposed to be broken, will aid in keeping the head of the bone in position, by making pressure over the trochanter. The bladder, of course, must receive early attention, and the urine be drawn if necessary. Pain and muscular spasms should be controlled by hypodermic injections of morphia, and antiphlogistic remedies employed to meet such inflammatory complications as may arise.

Fractures of the Lower Extremity.

There is some difference of opinion among writers as to the relative frequency of fractures in the upper and the lower extremity. Of 1572 fractures registered at the Calcutta Native Hospital during a period of twenty-one years, 681 were of the lower and 665 of the upper extremity.* Malgaigne analyzed 2328 fractures from the records of the Hôtel-Dieu, and found 1006 belonging to the lower and 850 to the upper extremity. Lonsdale examined the fractures at the Middlesex Hospital for six years. There were treated 1901, of which 516 were of the lower and 764 of the upper extremity.† In Lonsdale's collection an account was kept of the walking cases, such as were dressed at the hospital but did not enter its wards, and consequently it forms the basis for a reliable estimate. Of 8662 fractures recorded on the books of the Pennsylvania Hospital, 3910 occurred in the lower extremity and 3760 in the upper; but these were all in-patients.

For the satisfactory treatment of fractures of the lower extremities, especially of the thigh, a fracture-bed and mattress are necessary. These have been particularly described (page 733), and need not again be referred to. These fractures may be divided into those of the *thigh*, the *leg*, and the *foot*.

Fractures of the Femur.

The femur is the largest bone in the skeleton, its construction rendering it capable of resisting a great amount of force. Before those important changes which are incident to advanced life take place in its texture, very great violence is required to sever its fibres.

The most convenient classification of fractures of the femur is into those of the *upper extremity*, those of the *shaft*, and those of the *lower extremity*.

In forty-four years—from 1830 to 1874—there were treated in the Pennsylvania Hospital 1181 fractures of the thigh, 143 of which were compound. In 885 of these, in which the sex was named, 745 were males and 140 females 152 occurred in boys under ten years of age, and the largest number (164) between the ages of ten and twenty. The mortality in the whole number

* Holmes's System of Surgery, vol. ii. p. 842. † Lonsdale on Fractures.

of 1181—which was 164—may appear somewhat heavy; but, when we consider the severe injuries which in very many of these fractures complicated the cases, it will not create surprise.

In frequency, fractures of the femur are ranked by Malgaigne first, by others about fifth in order, as compared with like injuries of the other bones of the skeleton, except in the case of children, in whom, according to M. Colon,* they stand second in order. They constitute about thirteen per cent. of the whole number of this class of accidents registered on the books of the Pennsylvania Hospital; that is, they occurred 1181 times in 8667 cases.

Fractures of the Upper Extremity of the Femur.

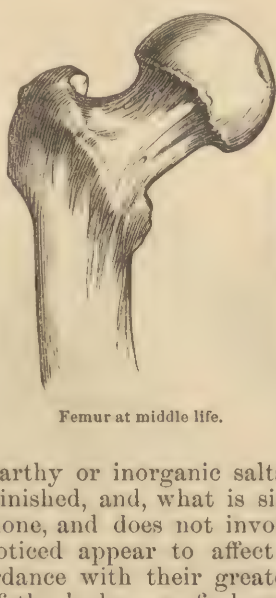
The proportion which fractures of the upper extremity of the femur bear to those affecting other parts of the bone was found by Bryant, at Guy's Hospital, to be about one-fifth, or 44 times in 207 cases. In the Pennsylvania Hospital it is about one-seventh, having occurred 171 times in 1181 cases.

The divisions under which it is proposed to treat these injuries are *intra-capsular*, *extra-capsular*, *mixed*, and *trochanteric* fractures.

Intra-capsular Fractures of the Femur.—Fractures which involve the neck of the femur, and which fall entirely within the insertion of the capsule of the joint, are called *intra-capsular.* They are peculiar to advanced life, and occur most frequently in females. These fractures are remarkable in two respects: first, on account of the trifling amount of force necessary for their production; and, secondly, for their failure to unite by bony matter.

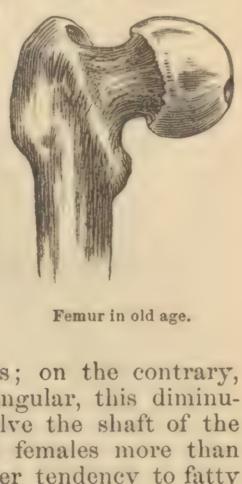
The causes of all cervical fractures are predisposing and exciting. If we compare the femur of middle life with one from a person of advanced life, a notable difference in the form of their upper extremities will be observed. In the bone of a person at middle life the neck is long, and joins the shaft at an obtuse angle, whilst in the bone of an old person the neck is smaller, and is placed more nearly at a right angle with the shaft. (Compare Figs. 746, 747.) This distinction is denied by Mr. Canton,† but I have had abundant evidence to satisfy me of its correctness. Not only is there this change in the form of the bone, but a very remarkable one takes place in its structure. As age advances, the nutrition of this part of the femur is greatly disturbed. The cells of the spongy tissue become rarefied and filled with fat, the compact tissue extremely thin, and the entire neck diminishes in size. Mr. Bransby Cooper‡ has shown that, whatever chemical alterations take place, the fragility of the neck cannot be attributed, as has been supposed, to an increase in the earthy or inorganic salts; on the contrary, these salts are very much diminished, and, what is singular, this diminution is confined to the neck alone, and does not involve the shaft of the bone. As the changes just noticed appear to affect females more than males,—a fact entirely in accordance with their greater tendency to fatty degeneration in all the tissues of the body,—we find accordingly the former

Fig. 746.



Femur at middle life.

Fig. 747.



Femur in old age.

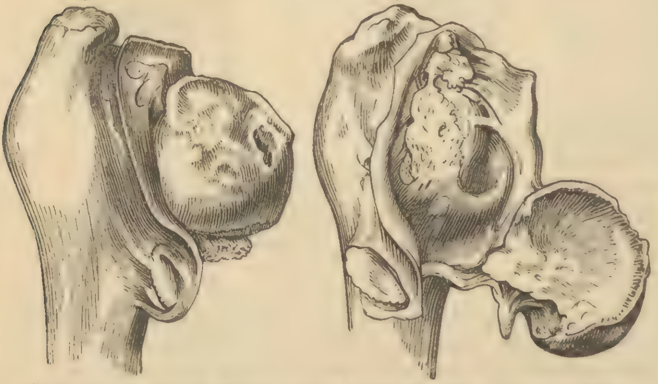
* Holmes's System of Surgery, vol. ii. p. 843. † Ibid., vol. ii. p. 847.
‡ Guy's Hospital Reports, 1845, 2d Series, vol. iii.

most frequently the subject of these fractures. This changed direction of the neck of the bones in the aged, especially in reference to the broad female pelvis, favors the accident, from the manner in which the weight of the body is transmitted to the femora. There is another change of the neck of the femur, the result of rheumatic arthritis, which, by the atrophy it induces, enfeebles the bone and renders it liable to be broken. Every year over fifty increases the probabilities of a fracture of the thigh-bone being intra-capsular. Sir Astley Cooper, in 251 cases, met with only two in which the patients were under fifty years of age. I have seen one case of the injury, proved by an autopsy, in which the patient, a sailor, was under forty years of age. As to the relative frequency of intra- and extra-capsular fractures, it must still be considered an open question. Malgaigne examined all the fractures of the cervix in the Dupuytren, St. Bartholomew, Dublin, and Richmond museums, making in the aggregate 103, and of these 61 were intra-capsular. Nélaton and Bonnet believed that extra-capsular fractures were very much the most numerous. In the museums of the College of Physicians of Philadelphia and the University of Pennsylvania there are 23 fractures of the neck of this bone, 10 of which are intra-capsular. Of 171 fractures of the upper extremity of this bone admitted into the Pennsylvania Hospital, 49 were intra-capsular.

Causes.—The exciting or determining causes are usually of a very trivial nature, such as falls upon the pavement, striking upon the knee or trochanter major, turning in bed while the foot is entangled in the clothing, or tripping upon the carpet while walking across the room. I have seen the femur broken by the muscular effort of pulling on a boot. Some importance is to be attached to the direction in which the force is communicated to the bone. M. Rodet,* by a series of experiments, came to the following conclusions: first, that force acting vertically—as when a person falls upon the feet or the knees—will produce an oblique intra-capsular fracture; second, that when acting from before backward it will produce a transverse intra-capsular fracture; and, third, that when acting from behind forward a mixed fracture, or one both within and without the capsule, will result. While these conclusions in many cases are correct, there are certainly numerous exceptions to this rule.

Pathology.—The fracture may traverse the neck at any point between the head and the attachment of the capsular ligament (Fig. 748), sometimes encroaching upon the head itself. The line of separation may be oblique (Fig. 749) or transverse, complete or incomplete. The periosteum often remains untorn,

Fig. 748.



a Complete intra-capsular fracture, of nine months' standing. *b* Same specimen, sawed.—Malgaigne.

Fig. 749.

Oblique intra-capsular fracture.

and serves to prevent displacement. An incomplete intra-capsular fracture has been doubted; but its possibility seems to have been established by Dr.

* L'Expérience, 14 Mar. 1844.

Jackson's case.* Another condition is that of impaction, one fragment—the lower—being forced into the spongy substance of the head (Fig. 750), or there may be a kind of dovetailing or mutual interpenetration of the pieces. Epiphyseal detachments from the head of the femur, in young subjects, have been asserted by Liston, and by several others since his day. Until this, however, has been verified by an autopsy, this accident cannot be regarded as established.

Fig. 750.

Impacted fracture; intra-capsular.—Bigelow.

The soft parts also participate in the injury. The reflected portion of the capsule is generally more or less torn; blood flows from the ruptured vessels; and, under the stimulus of the injury, the joint will be filled with synovia and serum, mingled with the effused blood. After several days, part of the blood will find its way towards the surface of the hip, and a subcutaneous discoloration appear. If there is much displacement or movement between the fragments, an inflammatory thickening of the capsular ligament will result, and in old cases nodules of bone may be seen incorporated with its substance. The broken ends may be loosely connected by fibrous tissue, or they may be bound together with considerable firmness. The head of the bone may be hollowed out by attrition with the lower fragment, and the latter be so rounded as to resemble slightly a ball-and-socket joint, or both ends may be entirely free and disconnected. In almost all cases where the fracture has existed for any considerable length of time, the neck of the bone, in a great measure, disappears. (Fig. 751.)

Fig. 751.

Neck of femur absorbed after intra-capsular fracture.

Symptoms.—The signs of intra-capsular fracture are the occurrence, after a slight accident in a person over fifty years of age, of pain, loss of power (or at least diminished power) of the limb, unusual mobility, deformity, crepitus, and swelling.

Pain.—This is usually acute, though not so severe as in fractures external to the joint, or in the shaft of the bone. It is felt extending from the groin a short distance down the thigh, and is due to injury of the articular branch of the obturator nerve. The movements which produce the most severe suffering are those of rotation. Patients frequently complain of pain on the posterior aspect of the hip near to the great trochanter, and also at the knee. When situated at the latter and persistent, it has been supposed to depend upon inflammation of the hip-joint, somewhat resembling coxalgia. While this, in exceptional cases, may be true, it is certainly far from being common. The connection which exists between the obturator and the saphenous nerves will explain the pain which is felt at the inner side of the knee after this accident.

Loss of function.—In regard to this particular symptom we meet with remarkable differences in different persons. Sometimes the patient is utterly powerless to flex or rotate the limb, or to move it in any position whatever; and if placed in the erect posture he is unable to bear the least weight upon the foot. In other instances, the leg can be raised from the bed; and frequently the patient can flex the entire limb by the action of the hamstring muscles,

* Boston Medical and Surgical Journal, vol. iv. p. 351.

which, as the heel is drawn up, also raise the thigh. The muscles which flex the thigh upon the abdomen are usually more disabled than those which flex the leg upon the thigh, simply because in the latter both the muscles and the nerves which endow them are more remote from the seat of injury. There are, however, some very remarkable exceptions to this symptom of disability. A case of intra-capsular fracture was admitted into the Pennsylvania Hospital in a patient under forty years of age, who, after the accident, not only walked to the institution from a distance of two squares, but also made his way to the third story of the building. A second patient, who was under my care, and who had a fracture within the joint, was for years always able to walk with a cane, and frequently without one. The verity of the injury was in both cases established by a post-mortem examination. These cases have been explained in various ways,—by impaction, by intercalation, and by an unbroken periosteum preventing a separation of the fragments. While these conditions no doubt occasionally do exist and confer the singular power which is possessed over the damaged limb, such is not invariably the case. In one of the patients just alluded to, the head of the bone had become deeply excavated by the action of the neck upon its surface, which served to prevent displacement of the fragments.

Preternatural mobility.—The ordinary methods of movement furnish but little information, as it must necessarily be a very difficult task, even with the keenest tact, to distinguish the movements of the fracture from those natural to the joint. When the limb is rotated, the trochanter will be found to describe the arc of a smaller circle than does the corresponding process of the sound side, inasmuch as the centre of motion is brought nearer to this prominence. M. Maisonneuve adopts a plan which gives a practical value to the symptom of mobility. He places the patient on the abdomen, and carries the injured thigh directly backward, in which direction, if it is broken, it will go much farther than when sound, as in the latter case this movement will be arrested by the neck of the bone striking against the margin of the cotyloid cavity.

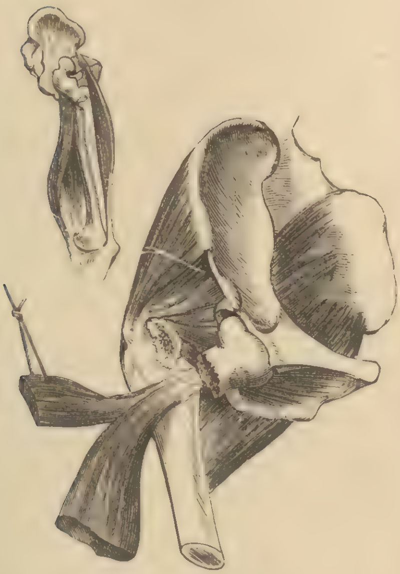
Deformity.—If the fragments are driven past each other, there will be shortening varying from half an inch to one inch, which may be increased to one inch and a half after the lapse of some time. This is due to the gluteal muscles recovering the power which had been temporarily abolished by the violence producing the fracture. It happens sometimes that there is no shortening whatever at the time of the injury, nor for some time after, when it appears suddenly and to a considerable degree. When this is the case, the fragments are not displaced at the time of the break, but by some motion on the part of the patient, some manipulation by the surgeon, or possibly some violent spasm of the muscles, the ends of the bone are suddenly disarranged, when the limb is drawn upward by the action of the glutei muscles, and inward towards the ilium by the pectineus, the adductors, and the conjoined action of the psoas and iliacus internus with the obturator externus muscles. (Fig. 752.)

Again, a shortening which is very gradual, and which may extend over a period of months, may occur without displacement, in consequence of a slow absorption of the cervix, induced under the stimulus of the lesion and the attrition of the contiguous surfaces. The cases of extreme shortening—two inches or more—which have been noticed by Sir Astley Cooper and others can only take place at the expense of the capsular ligament,—that is, by its extension or by its rupture. Cases of this nature, however, are exceedingly rare. With shortening of the limb there is also a change in the position of the trochanter major. It is brought nearer to the crest of the ilium and becomes less prominent. A moderate degree of extension, provided there is no impaction, overcomes the shortening, which returns, however, as soon as the force is withdrawn. If the fragments are displaced, some undue fullness of the groin may be detected in consequence of the upper fragment pressing forward.

Dr. Allis, of this city, has called attention to another diagnostic sign of this fracture, or, indeed, of any fracture through the neck of the femur,—namely, the existence of a relaxed condition of the fascia lata between the crest of the ilium and the trochanter major on the injured side, consequent on the loss of the resistance which is furnished by the unbroken cervix. Fig. 753 will illustrate the difference in the tension of this fascia in the two sides.

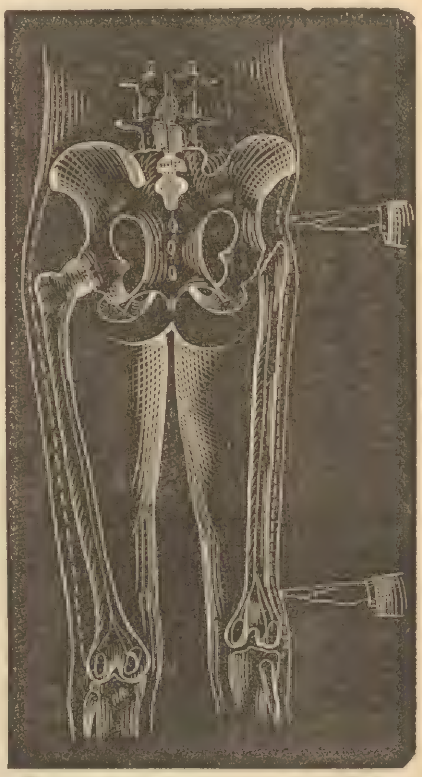
Eversion of the foot or *external rotation* of the limb constitutes another part of the deformity. This must be distinguished from the slight outward direction of the toes, which is the natural position of the limb when left unrestrained. The rotation alluded to is complete, the foot lying on its outer border, which deformity may be exaggerated by the hand, as pointed out by Gerdy, until the toes look backward,—a position impossible to the sound limb if the pelvis remains fixed. The eversion of the foot or the external rotation of the limb is due to three causes: first, to the action of the external rotator muscles, the tendons of which are inserted into the trochanteric fossa; secondly, to the absence of that resistance which is furnished by the ligamentum teres; and thirdly, to the weight of the limb.

FIG. 752.



Displacement following fracture through the neck of the femur.—Hines.

FIG. 753



The dotted line represents the fascia lata, its insertion, and manner of passing over the great trochanter. In the right limb the fingers indicate the points where it is most lax in case of fracture.

There are occasional exceptions to this external rotation after fracture of the neck of the thigh-bone, cases in which the foot may turn only slightly outward, or may stand vertically, and in a few instances may be even inverted. With regard to the first two positions, the explanation must be sought for in one of three conditions, viz., an unbroken periosteum, intercalation of the spicula, or an impaction of the fragments.

As to inversion of the foot, although I have never seen a case of the kind, the fact of its existence cannot be doubted, as we have the testimony of Paré, Petit, Stanley, Guthrie, Dupuytren, Malgaigne, Robert Smith, Hamilton,

Bigelow, and others, to establish the verity of this deformity. In Stanley's case an autopsy proved that the fracture was intra-capsular, as was the case also in those of Bigelow and Robert Smith.

Erichsen ascribes the non-eversion of the foot in these cases to paralysis of the external rotator muscles. Such a relation of the fragments as resists external rotation, apparently, can only be determined by the vulnerating force being applied in a particular direction, namely, on the posterior aspect of the great trochanter, by which the limb will be turned inward at the time that the fracture takes place.

Robert Smith states that when such anomalous positions of the foot exist, if extension is made sufficiently energetic to restore the limb to the proper length, external rotation will immediately follow as soon as the extending force ceases to act. This is confirmatory of the opinion that this inversion of the foot is due to a certain interlocking of the fragments.

Crepitation.—This important symptom is often recognized with difficulty. Various directions have been given as to the best method of making it sensible. That of Sir Astley Cooper consisted in extending the limb to its proper length, so that the broken surfaces may be brought opposite to each other, and then rotating the leg inward and outward. I have always met with the best success by flexing the thigh to almost a right angle with the pelvis, and then rotating it while traction is being made, the finger and thumb of the other hand at the same time embracing the articulation. Persistent efforts to establish crepitus may be productive of evil, by rending any periosteal bands which serve to keep the broken ends together, or by disengaging an impaction, which, had it been allowed to remain, might have been followed by bony consolidation. Hence prolonged manipulation is to be deprecated.

Prognosis.—Intra-capsular fractures, being peculiar to aged persons, and remaining ununited, as first shown by Sir Astley Cooper, must be regarded as very serious accidents. The dangers which threaten life arise from a kind of hectic fever, from bed-sores, inflammation, and abscess of the joint, wearing the patient out in a few weeks or months. The possibility of bony union in these fractures has been discussed with no little warmth at various times. The careful investigations of Sir Astley Cooper and the searching analyses of Hamilton are quite sufficient to show that bony union, while it is possible under certain favorable conditions,—such as an unbroken periosteum, or, according to Bigelow, an impaction,—is so exceedingly rare as in no way to invalidate the truth of the general law of non-union. We learn from Hamilton* that the whole number *claimed* by European surgeons is nineteen, and about the same number are in this country. Two of the latter belong to Philadelphia. Fig. 754 is a representation of one of these. This specimen, however, has recently been sawed in half, and found not to be a case of bony union.

Fig. 754.

Prof. H. H. Smith's case of supposed bony union after an intra-capsular fracture.

To determine with certainty the true relation of a fracture to the capsular ligament by dissections made months or years after the accident is no easy task. A portion of a fracture may be partly external to the capsule and escape detection. Dr. George K. Smith† has shown that the attachment of the capsular ligament is not uniform in dif-

* Fractures, etc., p. 364, 1871.

† Insertion of the Capsular Ligament, etc., Philadelphia Medical and Surgical Reporter, 1862.

ferent persons; therefore, to arrive at certainty as to these intra-capsular fractures, it has been very properly advised that the particular specimen in question should be compared with its fellow femur, and not with that of another individual. When these facts are considered, with others which might be mentioned, such as senile atrophy (Fig. 755) and arthritic disease of the cervix, there is a very strong probability that the number of alleged specimens of bony union might be still further reduced.

Fig. 755.

Senile atrophy of the neck of the femur, resembling intra-capsular fracture.

The question naturally arises, Why does union not take place? Several reasons exist for this, among which may be mentioned the following:

1. Deficient vascularity. The vessels which supply the head of the bone enter its substance by the ligamentum teres and the reflected portion of the capsule, and when the fracture takes place it must depend entirely for its vitality upon the arterial branch which ascends the round ligament,—a supply barely sufficient for its own existence, and sometimes not equal to that.

2. Whatever reparative material may be deposited has no local permanence; that is, there are no interlacing threads of connective tissue about the fracture which can serve as a nidus for its reception and support while passing through the stages of development.

3. Any reparative material furnished by the vessels becomes so diluted by intermixture with the increased synovial fluid as to be incapable of progressive organization.

4. Maladjustment of the fragments, or imperfect coaptation, and an inability to maintain that perfect quietude so necessary to the repair of these injuries, also militate against union. These causes, together with the action of the numerous powerful muscles which have their attachment near to the fracture, and which are disposed about the joint in the most favorable directions for disturbing the lower fragment, constitute the chief reasons for non-union.

Age, except in so far as old and infirm persons bear fixed confinement badly, can scarcely be regarded as inimical to the repair of bones, inasmuch as we constantly see fractures in other parts of the osseous system get well as quickly in the old as in the young. In some cases the principal obstacle to union consists in the fact that no provisional callus is thrown out by the periosteal vessels.

When patients recover sufficiently to get about, the disability will be found to vary greatly. Some are unable to allow any weight upon the limb, and it hangs uselessly by the other, being a little flexed; others, with the assistance of crutches, can move about with comparative ease; others can do the same thing with only the aid of a cane, although they are conscious of the limb yielding whenever the weight of the body rests upon the foot.

Pathology.—The changes which take place in intra-capsular fractures vary much in different cases. The immediate effects of the injury are hemorrhage into the joint, though not profuse, as the vessels are neither numerous nor large; shortly after, inflammatory phenomena set in, which, as in inflammation of joints from other causes, is followed by an increased amount of synovial fluid, mixed with serum, and, still later, with flakes of lymph. The ecchymosis which occasionally is seen diffused through the superficial cellular tissue comes from the vessels of this structure, and is the result of direct injury. When the fracture is effected by a twist of the limb, or by indirect force, it is not common to meet with discoloration, as there is not sufficient blood to find its way to the surface, in addition to which, there is the mechanical obstacle of the capsule to its escape. It is not often that this capsular ligament is torn. After a time, the redundant exudations and extravasations

are absorbed, and then the work both of repair and of destruction begins. If the apposition is favorable, the fragments may be connected by fibrous bands, which will allow of much play between their extremities; or there may be a bond, similar in nature, interposed between their broken surfaces, so firm and compact as to allow of but little movement (Fig. 756); or the fragments may remain entirely disconnected, and undergo different changes. Those which are more especially the result of vital activity take place in the lower fragment; that is, its broken surface may become incrusted with cartilage, or ruddy with a layer of granulation tissue, or its cervix materially thickened by external or periosteal deposit, or it may become concave or concavo-convex, thus conforming to the surface of the other fragment. The upper or acetabular fragment, from deficient blood-supply, becomes wasted, and even, it is said, sometimes entirely disappears, as in the two cases reported by Brunninghausen and Banco.*

FIG. 756.

Ligamentous union of intra-capsular fracture.—Mayo. From Sir Astley Cooper.

The capsular ligament, teased and stretched by the mobility of the fragments, may become thickened, and even ossified, so as to offer great resistance to pressure, while at other points it may become thinned, or possibly absorbed by contact with a spiculum, or by some salient point of one of the fragments.

TREATMENT.—The treatment of intra-capsular fracture has formed the subject of considerable difference of opinion. With Sir Astley Cooper it consisted in simply supporting the limb, moderately flexed, on a kind of double inclined plane, made of pillows, and after the immediate effects of the accident were past, say from twelve to fifteen days, directing the patient to sit up, and as soon as possible to begin to move about on crutches. Mr. Erichsen advises a similar plan of treatment, and some American surgeons recommend the same course. I do not, however, think that this practice is very largely adopted by the profession on this side of the Atlantic; and there are strong reasons, in my judgment, why it should not be. There have been recorded a sufficient number of cases of bony union after what was *believed* to be intra-capsular fracture, to justify a hope that some of the cases encountered by the surgeon may have a similar termination.

There is cause to assume that in these favorable cases the lesion was partly external to the joint, and hence the osseous consolidation which followed. Yet the very uncertainty on this point, in any given instance of articular fracture, is a sufficient reason for the plan of treatment advised.

I adopt the rule of treating every case of fracture of the femur, except that at the upper third, as though it were situated in the shaft of the bone, namely, by placing the patient on the back and applying extension with the limb in the straight position, after the manner to be presently described. I know of no position more comfortable than the one just named; and so long as it is endured without the patient being threatened with bed-sores, or without other evidences of constitutional feebleness, it should be maintained until the question of union is determined. If, however, the health shows a tendency to give way, the horizontal position on the back must be abandoned and the patient be laid upon the sound side, with the limbs flexed, or be placed in a high reclining chair and wheeled into the open air; or, if physically able, he may walk about on crutches. Nutritious food, tonics, and stimulants will be required to sustain the patient's strength. If there is reason to believe that the fracture is an impacted one, care must be taken not to disengage the fragments, either by officious manipulation or by the

* Malgaigne, Fractures and Dislocations, Packard's trans., p. 547.

addition of too much weight to the extension apparatus. Five pounds will be sufficient in most cases to keep the limb in position.

If the treatment is well borne, and there is evidence of the bone becoming firmer, it will be necessary to keep it up for a longer period than is commonly employed in other fractures of the thigh. If the patient is far advanced in life, and at the same time feeble and broken down in health, it would be obviously improper to attempt any plan of treatment which involved much restraint. Under these circumstances, it is better to consult the patient's comfort by resorting only to those expedients which will best subserve this end. For this purpose the limb should be placed over, and secured to, a double inclined plane, formed either by the splint of that name or by pillows, as in Fig. 757.

FIG. 757.

Limb placed over a double inclined plane formed by pillows.—Smith.

Extra-capsular Fractures of the Neck of the Femur.—Fractures of the neck of the femur external to the capsular ligament have many points, symptomatically considered, in common with those within that ligament.

The causes which produce this lesion are generally such as act directly upon the great trochanter, as falls upon this part of the hip, although sometimes the violence may be dual, being transmitted from a more distant part of the limb, as the knee or the foot.

The laws which govern fractures, while they always operate in entire consistence with established mechanical principles, can never be formulated with absolute accuracy, because, while intensity and direction of force may be measured, no two persons ever present exactly the same condition of osseous tissue; and yet in these extra-capsular fractures there is a remarkable uniformity.

FIG. 758.

Fracture in the course of the intertrochanteric lines.

FIG. 759.

Transverse fracture.

The line of separation usually runs in one of three directions. *First*, oblique,—that is, parallel with the direction of the anterior and the posterior intertrochanteric lines (Fig. 758), in which case the head and neck make the upper, and the trochanters and shaft the lower fragment. This variety of fracture, I think, usually results from indirect force, as where it is applied to the knee or to the foot.

Second, the line of separation may be transverse, and lower down at its outer than at its inner extremity (Fig. 759), making two fragments, the upper

one consisting of the head, neck, and a portion of the trochanter major, and the lower one formed by the shaft of the bone.

Third, the fracture may be comminuted, in which case there are three or more fragments, the head and neck forming the upper piece, the great trochanter making the second, and the shaft a third. (Fig. 760.) This injury is often the result of force applied to the trochanter major, the resistance being at the acetabulum, the comminution resulting from the neck being driven into the spongy tissue of the trochanter major, splitting it off from the shaft of the femur.

When the neck is buried in the cancellated tissue of the trochanter and the shaft of the femur, it forms an impacted fracture. (Fig. 761.)

Fig. 760.

Comminuted extra-capsular fracture.—Malgaigne.

Fig. 761.

Impacted fracture of the neck of the femur.—Miller.

Both Malgaigne and Robert Smith believe that all extra-capsular fractures, with detachment of the trochanter major, are impacted. Bryant concurs in this opinion; but Hamilton does not accept this statement unreservedly. There are three specimens in Philadelphia—one in the Mütter collection of the College of Physicians, one in the possession of Professor John Neill, and one in the museum of the University—which certainly prove the contrary. Instances have been recorded in which the lower fragment is said to have been driven into the upper one; but such must be exceedingly rare. The depth of penetration will depend upon the intensity of the fracturing force and the brittleness of the cancellated structure into which the neck is driven. It rarely exceeds three-quarters of an inch. The firmness with which the neck is held, when once forced into the intertrochanteric tissue, will depend in some degree upon the integrity of the strong interlacing bands of fibrous tissue which are connected with this part of the bone, and which are derived from the tendons and fascia about the trochanteric lines and fossa. If this fibrous tissue be torn, the trochanters fall apart, and the neck, instead of remaining imprisoned, will escape from the interspace, either by the fracturing force, by the movements of the limb, or by the manipulation which may be practiced. If, on the contrary, these ligating fibres remain intact, the penetration will likely remain.

Symptoms.—The resemblance between the phenomena of these fractures and those within the capsular ligament is such as to demand the greatest circumspection in the diagnosis. We have pain, swelling, discoloration, disability, crepitus, and deformity.

Pain.—This is more severe than when the fracture is within the joint; the tenderness is also more diffused about the peripheral portions of the articulation.

Swelling and discoloration are also more uniformly present. The ecchymosis is, in most cases, particularly marked, and comes, when the violence is

direct, from two sources,—one subcutaneous, and the other from vessels about the bone,—the latter finding its way to the surface after a few days, not being restrained by the limitations of the capsular ligament, as in intra-capsular fracture.

Disability.—On this point writers are at variance, and not without reason, for the degree of disability differs very much in different persons. I have seen a case in which the person could not only stand, but could bear his weight upon the foot; and I have also seen a patient with such a fracture utterly incapable of making any voluntary movement of the limb whatever. The loss of power generally, however, is greater than in the intra-capsular variety.

Crepitus.—This is a sign of uncertain value when considered in connection with such an injury. When the impaction is firm it cannot be detected. When the fragments are loosely connected, or when they are entirely detached from each other, it is easily elicited by rotatory movements of the limb. It is proper here to enjoin caution as to persistent efforts being made to discover this symptom, as an impaction may be unlocked and marked displacement follow.

Deformity.—This symptom manifests itself in various ways. There is shortening, varying from one-quarter of an inch to one inch; but when the impaction is not maintained, the neck may slip down the shaft, and the shortening be increased to even two inches. If there is no impaction, and the great trochanter is not detached, the latter process will be drawn up towards the crest of the ilium by the gluteus medius and minimus, together with the psoas and iliacus internus muscles, increasing the shortening and raising the neck until it is placed at a right angle with the shaft. If the great trochanter is split off, and so liberated from the other fragment or fragments as to be movable, it may undergo various changes of position,—that is to say, it may be drawn inward by the gluteus medius, or upward by the gluteus medius and minimus and by the pyriformis, or rotated outward by the obturator internus, quadratus femoris, and the two gemelli muscles, so that this part of the bone will appear to have an unusual breadth. Malgaigne once found it displaced towards the sciatic notch, and but for crepitus would have diagnosed a luxation. It may be stated in general that the more pieces and less impaction, the greater will be the shortening, and that this shortening is little, if at all, increased by the lapse of time. *Eversion* is a second element in the deformity. It is met with in all degrees, from the slightest turning out of the toes, to the position upon the outer side of the foot, depending upon the mobility at the seat of fracture. The opposite position of internal rotation of the limb, or inversion of the foot, is sometimes present, and there are reasons for believing that it is more frequently seen in this fracture than in fractures within the capsule. Robert Smith found that of seven cases of fracture of the cervix in which there was inversion of the foot, five were extra-capsular, while it was present only three times in fifteen cases of the intra-capsular variety. There can be little doubt that the force which produces the fracture, and the relation of the pieces, have more to do with this than muscular action.

Diagnosis.—To recognize clearly a fracture through the neck of the femur, or to assert with positiveness that such a fracture is present, is often a matter of no small difficulty, and occasionally one of impossibility; nevertheless a very careful consideration of all the phenomena of such an accident will, I believe, in most cases enable us to arrive at a just conclusion. The injuries which may embarrass the diagnosis are *fractures of the acetabulum*, *absorption of the neck of the femur* the result of arthritic or other changes in the nutrition of the bone, described by Mr. Adams,* and *luxation.*

In *fractures of the acetabulum* sufficiently free to allow the head of the bone to sink in towards the pelvic cavity, crepitus and some degree of shortening may be recognized. The arc described by the trochanter will indicate a shorter radius than that of the sound side; and while extension will restore

* Cyclopædia of Anatomy and Physiology, vol. ii. p. 789.

the limb to its proper length, yet on the withdrawal of the force the shortening will reappear. In fractures of the acetabulum, shortening and crepitus may not be detectable, but the same is occasionally true of fractures of the cervix. In fractures of the acetabulum the foot may be inverted or everted. The same is true of those involving the neck. When all these facts are considered, I am quite willing to confess that an error of diagnosis, even on the part of a skilled surgeon, is not only possible, but also altogether excusable.

Again, in those *interstitial changes* which are met with in the neck of the femur as the result of arthritic or traumatic inflammations, by which the neck and sometimes the head are partly absorbed, how similar are the symptoms to those of cervical fracture! After a severe contusion of the hip, the neck of the bone may undergo a slow absorption, which will be followed by shortening; and if in consequence of rheumatic or other changes the articulating surfaces become eburnated, even crepitus may be elicited and pain experienced when the head of the femur is moved in the cotyloid cavity.

In the case of Hare against Professor John J. Reese for malpractice, before Judge Thayer, of Philadelphia, there were strong reasons for believing that the neck of the femur had undergone such interstitial shortening.

In a case of this nature a differential diagnosis may be established with some certainty. Thus, it will be found, on a close examination, that the shortening has been progressive, and did not exist at the time of the injury. This may be true also of a fracture of the neck; but the shortening is much slower in the first, and extends over a much longer period of time. Crepitus, when it is discovered in interstitial change, is only revealed after many weeks succeeding the injury, as time is demanded for that surface-change (eburnation) which is requisite for its development. In cervical fracture, after a few weeks, it is not probable that crepitation can be made apparent, although I was able in one case both to feel and to hear it after two months. A still more important distinction is to be found in our ability to remove the shortening of the limb by extension in fractures of the neck, but not so with the shortening which accompanies interstitial disease. Discoloration of the soft parts may attend both. In the first, it is from the vessels of the subcutaneous tissue, and appears in a few hours after the accident; while in fractures, especially extra-capsular, an increased or secondary ecchymosis will show itself several days after the injury, coming from the vessels about the bone, being thus delayed by the superincumbent strata of tissue through which the blood is compelled to pass.

Again, there may be a fracture of the lip of the acetabulum which will allow the head of the femur to become *luxated*. Here we may have shortening, correctable by extension, but returning on its withdrawal, as in fracture. Crepitus may also exist. In attempting to establish a distinction, due weight should be given to the fact that fractures of the lip of the acetabulum are very rare at such an age as predisposes to fractures of the neck, that the limb possesses less mobility than when broken, and that once reduced the shortening can be prevented without extension by turning the head of the bone towards the side of the acetabulum opposite to the supposed fracture.

While there is often, therefore, some uncertainty in coming to a full understanding of the exact character of injuries about the hip-joint, yet we can pronounce with considerable certainty upon intra-capsular and extra-capsular fractures. By contrasting the peculiarities of each when placed in juxtaposition, as is done in the table on the following page, and also by comparing these with posterior luxations, clearer ideas may be gained of their distinctive peculiarities.

Intra-capsular Fracture.	Extra-capsular Fracture.	Posterior Luxations.
1. Produced by trifling violence at any point of the limb.	Considerable violence, most frequently upon the great trochanter.	Great violence applied to the knee, the thigh being in a state of adduction.
2. Sex.—Most common in females.	Sexes about alike as to frequency.	Most frequent in males.
3. Age.—Fifty and upwards.	Under or over fifty.	From fifteen to forty-five years of age.
4. Position.—Foot rests on its outer side.	Rests on its outer side; if impacted, may be at any degree of eversion.	Limb inverted and adducted.
5. Shortening.—Very variable; may be none; generally not over one inch. May occur suddenly or gradually; readily removed by extension, and returning when force is removed.	From a quarter of an inch to one inch; may increase, but, if impacted, remains the same. Moderate extension will restore the limb to its length; if impacted,. requires much force to do so.	From one and one-half to two inches. When restored to its proper length by extension, the shortening does not reappear.
6. Mobility.—Very great.	Mobility great, unless the fracture be impacted.	Limb more fixed and rigid.
7. Crepitation.—Not very distinct.	Distinct, unless impacted.	No crepitation.
8. From summit of great trochanter to the tuberosity of the femoral condyles no shortening.	Shortening usually between these points.	No shortening.
9. Pain.—Not severe; felt most, near to the trochanter minor.	Generally severe, and felt over the trochanter major.	Not severe, but extending down the back of the thigh.
10. Disability.—Great.	Disability greater, but may bear, if impacted, some weight on the foot.	Helpless; cannot endure the least weight on foot.
11. Contusion and discoloration.—Little.	Often much.	Rarely any.
12. Wasting of the limb and continued weakness.	Little, if any, wasting; regarding its strength, weakness temporary.	

Prognosis.—When the patient has sustained slight injury beyond the fracture, very little apprehension need be entertained as to recovery. The mortality at the Hôtel-Dieu,* namely, one in every three cases, is extraordinary. No such mortality exists in any American hospital; and possibly it may be due, as Malgaigne asserts, to the plan of treatment pursued in this institution. The period at which death takes place in fatal cases varies from two weeks to two months.

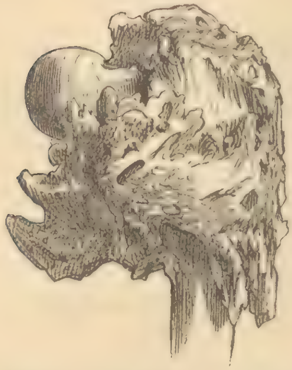
Of the 176 fractures of the neck of the femur recorded in the Pennsylvania Hospital (exclusive of the crushes of the pelvis), only 9 died, and of this number 49 are recorded as intra-capsular, only 2 of which died: in private practice, where the ordinary comforts of life and judicious professional attention can be secured, death is rather uncommon. Consolidation of the fragments will take place in about the same period as in ordinary fractures of the shaft, though some lameness may be expected. The amount of spongy and irregular callus which, in many instances, is thrown out, is truly wonderful, and particularly if union does not take place. It sometimes conceals much of the upper fragment, forming a deep recess, into which the neck of the bone is lodged as in a socket. (Figs. 762, 763.) This callus is derived from the vessels of the lower fragment, where there is, of course, a large amount of cancellated tissue for its supply.

Treatment.—The same rule is to be adopted in the treatment of extra-capsular fractures as in that of those within the joint, namely, extension by means of adhesive plasters with a weight attached, and by lateral support with sand-bags, as will be described under the head of fractures of the shaft of the femur.

* Malgaigne, Fractures and Dislocations, Packard's trans., p. 561.

Care must be taken not to attach too much weight to the limb when impaction is suspected, since otherwise the fragments may be disengaged and a

Fig. 762.



Excessive callus following an ununited extra-capsular fracture.—From a specimen in the University Museum.

Fig. 763.

Redundant callus in an ununited extra-capsular fracture.—Hamilton.

great advantage be lost. Whenever the shortening does not exceed one-half or three-quarters of an inch, and is not overcome by a reasonable degree of force, the inference is that such impaction exists. We should therefore be content with a weight of five or six pounds, merely to keep the limb securely extended. The position of the foot must be changed from that of eversion to the perpendicular, or to one in which the toes are directed upward. This is sometimes done by passing a strip of muslin about the toes and making it fast to some permanent object, such as the mattress or one of the sand-bags. A much better plan, in fractures of the neck, is to slip behind and beneath the great trochanter a small sand-bag ten or twelve inches long and four inches thick.

Should adhesive plasters not be immediately available wherewith to apply the above-mentioned dressing, resort may be had to the double inclined plane, or to Desault's apparatus as modified by Physick or Hodge.

Should the person be aged and infirm, and begin to fail under the restraint, all forms of surgical appliances must be abandoned, and that position assumed which will conduce most to the comfort of the patient.

Fractures of the Trochanter Major.—The trochanter major may be broken off from the shaft independently of any other injury to the bone. The accident is a very uncommon one. In 1181 fractures of the thigh treated in the Pennsylvania Hospital, this injury was recognized only four times. Some confusion exists as to the exact nature of this fracture. That described by Sir Astley Cooper as "a fracture through the trochanter major" is more properly a fracture of the upper extremity of the shaft, passing through the great trochanter, its course being downward and inward and not in any way implicating the neck of the bone. It would be quite as proper to designate fractures of the neck, with splitting off of the trochanter, as "fractures of the trochanter major." Nor is the confusion relieved by reading his description of the case seen with Mr. Harris, and also with Mr. Brodie.* It would appear that in this patient there was neither crepitus nor shortening, and that after one month he found the trochanter had fallen

* Cooper on Luxations and Fractures, Godman's edition, p. 129.

some distance behind its natural position, but was easily lifted into place by the hand. How could such be the case and yet no shortening follow, if it is meant to convey to the reader the idea that this fracture extended through both shaft and trochanter? The inference would rather be that this was a fracture simply detaching the latter process from the shaft. If, however, the fracture passes across the shaft and the great process, the extent of surface exposed and the fibrous expansion derived from the contiguous tendons would tend to prevent displacement, in which case there would be no shortening, and it might be also impossible to elicit crepitus, so that the accident might escape detection. In Cooper's case it was only revealed by dissection.* If displacement of the fragments should be present, the summit of the great trochanter would remain fixed or be but little affected upon rotation of the limb; the leg would be shortened by the contraction of the gluteus maximus; the foot would be everted by the weight of the limb, and when the latter was drawn down and rotated, crepitus would be discovered. Strictly speaking, fractures of the trochanter should be confined to a separation of the epiphysis, or to its detachment from the shaft.

Fracture of the Epiphysis of the Great Trochanter.—Fracture of the epiphysis is an exceedingly rare occurrence. In my own collection is a well-marked example of the injury, accompanied by a fracture of the condyles (Fig. 764): this, and one reported by Mr. Ashton Key, appear to be the only instances of the kind which have been verified by an autopsy. The cases narrated by Clark† and by Bransby Cooper,‡ although the first was examined after death, Hamilton thinks were impacted fractures of the neck. I can scarcely believe that Clark's case can in any way be construed into one of fracture of the neck, with impaction. It was certainly a comminuted fracture of the great trochanter.

Fig. 764.

Fracture of the epiphysis of the trochanter major, with a fracture of the condyles.

Cause.—The cause of this fracture is force applied over the process, as when a person falls violently upon the hip. It is by no means peculiar to the aged, having occurred, in Key's case, at the age of eighteen,—before which age the epiphysis had become solidly united to the shaft,—since this consolidation occurs shortly after puberty. In Clark's case the patient was thirty-two. In my own there was no history, the bone having been taken from a subject in the dissecting-room.

The *symptoms* of such an injury are, pain experienced on movement of the limb, diminished prominence of the great trochanter, and its fixed condition uninfluenced by the movements of the shaft. When grasped by the fingers, the process will be found movable, and if released from the tendinous expansion of the vastus externus, its displacement upward and backward by the gluteus medius and minimus will follow. Lastly, crepitus will be felt when the limb is strongly drawn away from its fellow and the trochanter fixed by pressure so as to bring the surfaces of the shaft and process into contact. As the continuity of the shaft and neck is not destroyed, there can be no shortening or external rotation of the limb.

Prognosis.—When the trochanter is entirely detached and much displaced, its union with the femur cannot be expected. This, however, could not permanently affect the usefulness of the limb, as the insertion of other muscles capable of producing nearly all the movements of the thigh would remain undisturbed. In the specimen which I have figured, there was present a con-

* Luxations and Fractures, p. 138, American edition, by Godman.
† American Journal of the Medical Sciences, Nov. 1836, vol. i. p. 181.
‡ Dislocations, p. 192.

siderable amount of granular callus around the circumference of the fracture, though there was none between the fragments.

Treatment.—So little is known in regard to these fractures of the trochanter, that I confess my inability, with all the light that can be obtained upon the subject, to designate any method of treatment established by experience; but, looking at the subject from a purely anatomical point of view, I can see no reason to depart from the extended position of the limb, as recommended for fractures of the neck of the bone. The leather bandage of Cooper, buckled about the pelvis, is certainly not likely to give any advantage in retaining the trochanter in place which might not be as well obtained by the use of a broad strip of adhesive plaster. The abducted position of the limb, recommended by Bransby Cooper, will scarcely suffice to bring the two pieces sufficiently near together for any practical purpose, though no possible objection can be urged against any attempt to effect this object in that way.

Fractures of the Shaft of the Femur.—Fractures of the shaft of the femur may occur at any point, but it is customary to speak of the bone as being divided into thirds: thus, we have its fractures referred to the middle, upper, and lower thirds. The middle third of the bone is most frequently the region of fracture. Holthouse states* that of 70 cases which he observed, 46 were in the middle, 16 in the lower, and 8 in the upper third. Hamilton makes a similar statement,† founded on the specimens in the Mütter Collection of the College of Physicians of Philadelphia. Of the 24 fractures of the shaft, 19 are in the middle, 3 in the upper, and 2 in the lower third. Of 539 fractures of the thigh received into the wards of the Pennsylvania Hospital, 269 were in the middle, 151 in the lower, and 119 in the upper third. The middle third of the bone is the smallest and weakest part; it is the summit of the arch, and whether the force be communicated directly or indirectly, it is within this region that it is most intensified. Its fractures are frequently compound, and sometimes comminuted. Of 1181 cases taken from the records of the Pennsylvania Hospital, 143 were compound, and of 885 classified and reported, 20 were comminuted. (See table.)

The direction of these fractures is generally oblique, and the obliquity is of considerable extent. In children, it is generally more transverse, as stated by Erichsen, than in adults; and even in the latter, when near the middle, where the compact tissue is greatest, we occasionally meet with a transverse fracture. The line of break varies also as to position. In the upper third of the bone there is no uniformity; in the middle third it is downward and inward, and in the lower third downward and forward, the upper fragment being generally in front of the lower. In children, fractures of the thigh are more common than are those of the leg.

Causes.—These are either direct or indirect. The direct are the most common, as when the thigh is struck by heavy pieces of timber, or by castings, or is run over by a loaded wagon, or when, as I have seen occur, a horse falls upon his rider. Indirect violence tends to produce fractures of the lower or the upper third, the force being transmitted through the leg, as when a person falls from a considerable height upon the feet; the same result may follow a fall upon the knee. Muscular action alone has been known to produce a fracture of the bone, as in Beauchère's case,‡ noticed by Holthouse, of a man who, to prevent himself from falling backward, made a violent muscular effort, breaking the bone just below the trochanter. The same cause, I have no doubt, produced a fracture immediately below the trochanter in a patient of my own, who, having tripped over a croquet-mallet, made a very energetic attempt to recover himself, when he heard the bone give way. I might also record a second instance of a fracture of this bone, occurring in the upper third of the femur, produced by turning in bed, the foot being entirely

* Holmes's System of Surgery, vol. ii. p. 860.

† Fractures, etc., p. 386.

‡ Beauchère, Jour. de Méd. de Leroux, t. xxx. p. 336.

free. In all these cases, however, there is a reasonable ground for believing that the bones were unsound, and this is rendered still more probable by the fact that these fractures, brought about by such slight causes, have been near to the upper extremity, where we know the bone is especially prone to degeneration.

Symptoms.—The following symptoms are common to all fractures of the shaft of the bone:

Pain, which is excessively acute, particularly on movement, and sufficiently severe to extort a sharp cry from the most resolute.

Preternatural mobility, which is easily discovered by raising the leg or the thigh, or by adducting or abducting the limb.

Deformity.—This may appear in the form of an unusual prominence, with shortening of the limb; it may consist in angular displacement of the fragments, in eversion—rarely inversion—of the foot, and in swelling, produced both by muscular contraction and by effusion.

Crepitus.—This is readily elicited by rotating the limb. An assistant should be instructed to make traction from the foot until the limb is brought to its proper length, and then to rotate the parts while the hand of the surgeon embraces the seat of injury and his ear is brought near to the same. This manipulation is particularly necessary when the fracture is somewhat transverse in its course. It is proper to say that when the other signs are sufficiently marked there can be little necessity for inflicting further pain simply to produce crepitation.

Disability.—The limb is usually helpless, the patient having little, if any, voluntary power to change its position. A part of the deformity, especially that of angularity, is due to the combined operation of muscular action, the violence determining the fracture, and the awkwardness or ignorance of those who may attempt to move the patient.

That which we speak of as shortening, or overlapping of the pieces of the bone, is the result, largely, of muscular contraction alone. This is well seen in those cases in which the accident follows direct violence, temporarily paralyzing the muscles. At first, very little shortening exists, but in a few hours, when they recover their power, it becomes quite marked. The obliquity of the fracture also favors the shortening. Instances of trifling shortening are occasionally met with, in which there is no subsequent tendency to increase,—a condition which is explained by the interlocking of certain prominent serrations of the fragments.

Prognosis.—When there is a simple fracture of the shaft of the bone, without other injury, a favorable result may be expected. When the injury is a compound one, and the patient old or broken down by irregular habits of life, the case assumes a serious aspect; and if, in addition, the knee-joint should be opened, the danger is greatly enhanced, and the prognosis becomes still more unfavorable.

In all cases of fracture of the femur, except in children, an appreciable degree of shortening may be expected. There has been much difference of opinion among surgeons on this subject, and very recently it has assumed a new importance from the prominence given to the matter at a recent meeting of the American Medical Association, held at Detroit, where it was declared, by a prominent surgeon, that under proper dressing there should be no difference in the length of the limbs. I think there are few surgeons who are prepared to accept this statement. Desault, Amesbury, South, Dorsey, and some others have claimed to accomplish cures without deformity of any kind, but when we interrogate the long line of distinguished men who have spoken on this subject, with few exceptions, from Hippocrates down, they utter but one voice,—viz., that shortening is the rule.

Velpeau was quite satisfied with half an inch shortening. Chelius says, "Even in the most satisfactory cases there remains a little shortening." Nélaton admits its uniform presence. Malgaigne writes as follows: "I must state positively that I have never obtained anything of the kind," al-

luding to the assertions of those who claim to cure fractures of the femur without shortening. Dr. Warren, of Boston, in a letter to Professor Hamilton, says, "I have never yet seen, either in Boston or elsewhere, an oblique fracture of the thigh in a patient over seventeen years of age in which there was not some shortening." Gibson writes, "In oblique fractures of the thigh, it is hardly possible, in any case, to calculate on union without more or less shortening." Hamilton, whose surgical skill is exceeded only by his candor, after a most careful examination of all the testimony at his command, concludes "that in an oblique fracture of the shaft of the femur in an adult, and where the muscles are not paralyzed, and where the ends have been displaced, no means have yet been devised by which an overlapping and consequent shortening of the bone can generally be prevented." Professor Gross says, "the opinion of many respectable practitioners, that it is impossible to effect a cure of fractures of the shaft of the thigh-bone without shortening, is only too well founded."

Mr. Holthouse, in the summer of 1857, examined all the fractured thighs under treatment in the different hospitals of London, making an aggregate of fifty,—thirty adults and twenty children. This examination was conducted with the greatest care; and the result reached was as follows. Only fifteen escaped deformity, and of these, twelve were children, but three adults of the thirty being without deformity, making ninety per cent. of adults and forty per cent. of children in whom shortening was present.

The same author further confesses that, with all his efforts to obtain a perfect cure at the Westminster Hospital, he has never succeeded in a single case where the patient was an adult; and in one hundred specimens which he examined of this fracture, distributed among the museums of London, only one was found free from deformity.* My own experience accords entirely with these statements. I have not met with a single case, among all the specimens in Philadelphia of fracture of the shaft of the femur, which was entirely free from deformity; and I am equally certain that neither in hospital nor in private practice, save in the case of children, have I ever succeeded in curing a case without an appreciable shortening.

The discrepancy which exists on this subject may be accounted for, in a measure at least, by the want of accuracy in measurement, as well as by the time when the mensuration is made. To be accurate, the crests of the ilii must be absolutely on the same level, and the measuring-line must be void of elasticity. The patient must be likewise entirely honest, as he has it in his power to practice a deception by inducing different degrees of tension in the extensor muscles of the two limbs, which is not detectable by the keenest observer. Lastly, the surgeon must himself be free from all bias,—a simple seeker after truth,—a state of mind which is not always easily reached. Again, it is not improbable that a bone will shorten somewhat for some time after a patient is discharged as cured, from the influence of the weight of the body upon the imperfectly-constructed callus.

With respect to the amount of shortening, in Holthouse's thirty-five cases it ranged from half an inch to three and one-third inches. In twenty-one specimens examined by myself, the average shortening did not exceed three-quarters of an inch. Hamilton's measurements yielded an average shortening of three-quarters and one-forty-seventh of an inch.

In reference to the subject of shortening, Dr. Cox, who made a large number of measurements—sixty—among the patients without fractures at the Pennsylvania Hospital, states that he found a marked disparity in the length of the two limbs of the same person.

It is to be understood that this disparity in the length of the two limbs is not real, but only follows in consequence of the difficulty in touching exactly corresponding portions of the skeleton on the two sides, from the varying position of the pelvic factor, and from unconscious muscular action on the part of

* Holmes's System of Surgery, vol. ii. p. 865.

the patient. Any one who will take the trouble to measure corresponding femora deprived of the soft parts will find them to be of equal length.

I do not hesitate to say that a fracture in the shaft of the thigh-bone which is cured with one-half or three-quarters of an inch shortening is a good cure, and gives no room for complaint on the part of the patient; and that the surgeon who obtains this result may walk among his professional brethren without being conscious of the least inferiority or want of skill in the management of this class of surgical injury.

Fractures in the Upper Third of the Femur.—These fractures are proverbially difficult of management, and are particularly prone to be followed by deformity. When close to the trochanters, they are frequently associated with fracture of the neck exterior to the capsular ligament. The chief difficulty is with the upper fragment, which undergoes different changes in different cases,—the most common being a displacement forward and upward by the action of the psoas and iliacus internus muscles and outward by the action of the same muscles, together with the gluteus minimus, pyriformis, obturator internus, gemelli, and quadratus femoris muscles. (Fig. 765.) When the upper fragment is tilted inward instead of outward, it is probably due to the direction of the fracturing force, the pectineus and adductor brevis muscles maintaining the bone in its abnormal position. Mr. Erichsen had three opportunities of verifying the truth of this explanation by dissections.* Should the fragments be so held together by wedging of the spiculæ, they are liable to be drawn outward so as to form an angle salient externally. The muscles which combine to effect such a displacement are the gluteus medius and minimus externally, and the adductor internally.

Fig. 765.

Displacement of the upper fragment of the femur in a fracture at the upper third of the bone.

Fig. 766.

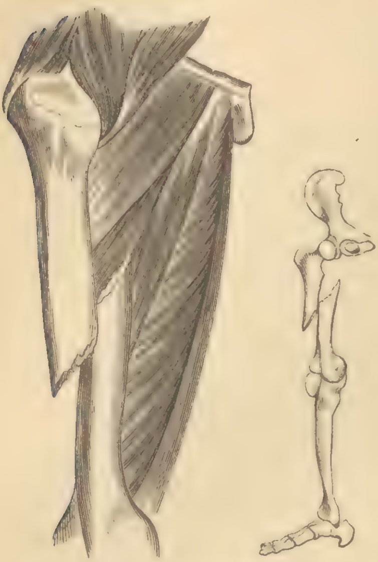
Deformed union of a fracture at the upper third of the femur.—Malgaigne.

The great difficulty in controlling the upper fragment is such that, although there may be no failure in the union, some degree of shortening of the limb, and consequent lameness, may be expected. In badly-treated fractures at the upper third of the bone, the anterior angular deformity may be very marked. (Fig. 766.)

* Surgery, vol. i. p. 374.

Fractures in the Middle Third of the Femur.—These fractures are much the most frequent of those occurring in this bone, but are not so oblique as are those in other portions, because here the compact tissue is greatest, and the size of the bone least. The line of fracture is very uniform, being downward and from behind forward; the upper fragment, in almost all cases, being in front of the lower one. Within this region also we occasionally encounter multiple as well as compound fractures. The shortening or overlapping is likewise very great, varying from two to three inches, and sometimes even more, with marked deformity, swelling, and eversion of the foot. The uniformity with which the upper is in front of the lower fragment is very noteworthy, and is the effect chiefly of muscular action; the psoas and iliacus internus advancing, in some small degree, the upper piece of the bone, and the adductor magnus and gastrocnemius drawing back the lower piece, while the overlapping is caused by the rectus, the hamstring, and the adductor muscles. The fracturing force and the weight of the limb should not be entirely excluded in the enumeration of these causes, though their influence must be of a very secondary kind. (Fig. 767.) Most of the cases of ununited fracture of the femur are seated in the middle third, though union, with some shortening, may confidently be expected in five or six weeks.

Fig. 767.



Fracture of the femur at the middle third, with overlapping, the lower fragment being behind the upper.

Fractures in the Lower Third of the Femur.—These follow either direct or indirect violence. The direction of the fracture is determined, in some measure, by the manner in which the producing cause operates. When from indirect force, as from falling on the knee or the foot, it will probably be oblique, running from above downward and from behind forward. When from direct force, as when a piece of timber falls across this part of the thigh, the line of separation will be more transverse. When the fracture occurs near to the knee-joint, the usefulness of the articulation may be seriously impaired. The displacement consists in the upper fragment being tilted forward and sliding down towards the joint in front of the lower piece. It may be seen or felt as a prominence on the front of the thigh, pushing forward the quadriceps muscle: should the end be pointed or sharp, it may penetrate or even pass through all the superincumbent tissues, and form a compound fracture. The lower fracture is generally represented as being drawn backward by the gastrocnemius muscle so as to be felt in the ham. (Fig. 768.) Malgaigne denies this altogether, and says there is not a specimen of such a displacement in any museum in Paris. If he is to be understood as meaning that the lower fragment does not fall somewhat back towards the ham, he is in error. I have never been able to discover any great encroachment upon the popliteal space, although the gastrocnemii muscles do tend to

Fig. 768.

Diagram illustrating the supposed displacement of the lower fragment of the femur.

draw this inferior fragment backward, but the action is limited in its operation.

The two vasti muscles, having their origin along the two branches of the entire linea aspera, and being inserted into the edges of the tendon of the rectus femoris, serve the part of a sling, which, with the expanded insertion of the adductor magnus, prevents the bone from falling or being drawn back to any great extent. No specimen in this city furnishes an example of any very marked posterior displacement of the inferior fragment; and, for the anatomical reasons already given, the deformity must be very rare. The overlapping of the broken parts, which produces the shortening, is caused by those muscles which have their attachments on the pelvis and the leg,—as the rectus in front, and the hamstring muscles posteriorly. Eversion of the foot—common to all fractures of the thigh—will be present to some degree in the one under consideration. In the reduction of this fracture, some address is requisite when the rectus is impaled, in order to disengage the upper fragment from the substance of the muscle. The method of Boyer, by extension and counter-extension in the extended position, will not always answer. The best plan is to follow somewhat that recommended by Malgaigne for the reduction of a fracture above the condyles: "Flex the thigh to nearly a right angle with the pelvis, and then, flexing the leg, with the forearm in the ham, make extension, gradually restoring the limb to the straight position."

TREATMENT OF FRACTURES OF THE SHAFT OF THE FEMUR.—*Preparation of bed.*—To secure a properly-constructed bed, where this is possible, is of the first importance. There are several expensive and very ingenious beds, which have been already noticed in an early chapter of this book, but which, from the fact that they are beyond the means of most persons, must be of very limited use. The iron fracture-bedstead, in common use in our hospitals, with an opening in the centre guarded by a trap, answers every purpose for our public institutions and in private houses. With the assistance of a carpenter a single bedstead may be very soon converted into a fracture one, by substituting for the middle slats a broad board with a hole cut through its centre, or two boards with a semicircular portion taken from each. On the under side nail two cleats, each with a shoulder, along which may be slid a tin bed-pan to receive the dejections. Upon this bed place a very firm mattress, from the centre of which has been cut out a circular piece six inches in diameter. This must be lined with oil-cloth, which shall cover likewise the upper and lower surfaces of the mattress for six or eight inches around the hole. In country districts the physician has frequently, as I know well from personal experience, to get along as best he may with very crude and imperfect appliances. Men whose lives have been spent in a city or in a hospital know little of the extreme simplicity of country practice or of the limited range of resources often at the command of the country practitioner, and it is to me a source of astonishment that his results are generally so good. It is quite possible to treat a fracture of the thigh on a soft bed which has been beaten down and covered with folded comfortables, and to dispense entirely with the usual arrangements for defecation by placing against the lower end of the bowel a firm wad of oakum or of tow on which to receive the evacuations, the act being effected in this manner without leaving a soiled spot on the bed.

The bed being arranged and covered with a sheet having a hole in the centre corresponding to that in the mattress, an upright containing a fenestra with a pulley (Figs. 769, 770) can be placed at the foot of the bed, or may be screwed fast to it, a little to one side of its middle. This upright must have several holes for the axle, so that the latter can be raised or lowered as may be found necessary. In the absence of a roller, a cotton-spool, with a strong piece of wire for an axle, will make a very good substitute. The patient being on the bed, and the fracture adjusted by the usual manipulations, the surgeon proceeds to prepare and apply his apparatus for extension. For this purpose a strip of adhesive plaster is cut, two and

a half inches wide, and long enough to extend from the upper end of the lower fragment on both sides of the limb and leave a loop some distance below the sole of the foot. When the roll of plaster is not sufficiently long, this extending band may be formed from two strips, which must be sewed firmly together where they overlap below the foot. On the middle of the spread surface is to be laid a piece of board two and a half inches wide, and sufficiently long to prevent the plaster from touching the malleoli. A second piece of plaster, eight or ten inches long, five inches wide in the centre, and two inches and a half on each side (Fig. 771), is next prepared. The wide central part of this strip is placed upon the inside of the foot-board, over the edges of which it is turned down, and the lateral portions are brought along the surface of the extending band as high as the malleolus on either side. The object of this piece is to fasten the foot-board securely to the extending band, and, by lining the inner surface of the latter for some distance on either side, to prevent the plaster from pressing upon and adhering to the malleoli. Thus prepared, the apparatus presents a stirrup-like appearance. (Fig. 772.) Three additional strips

FIG. 769.

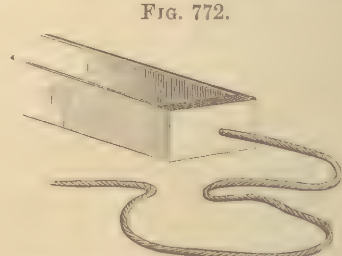
FIG. 770.

Uprights for pulley.

FIG. 771.

Form of the short strip for fastening the foot-board to the long extending band.

FIG. 772.

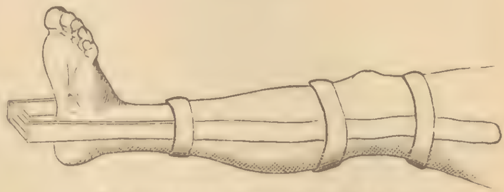


Extension apparatus ready to be applied.

of plaster are next required, two inches wide, and sufficiently long to encircle the limb,—one above the ankle, one immediately above the calf of the leg, and the third a short distance above the knee. A cord should be then attached to the foot-board, through a hole in its centre, or a piece of a roller may be tied around the stirrup, to either of which the extending weight can be tied. Bags for lateral support are also to be provided. Two of these are required,—one to extend from the foot to the perineum, the other from the foot to the axilla. These may be quickly prepared by taking strong twilled muslin, about fourteen inches wide, sewing it upon the sides and at one end, so as to make a long narrow bag, then turning it so as to have the seams inside, and, after filling with dry sand, either to sew or tie the unclosed extremity. These bags must not be filled too tightly, otherwise it will be impossible to shift their contents so as to make them conform to the outline of the limb. One or two rollers, two and a half inches wide and eight yards long, with two or three bricks, being provided, the appareil may be considered complete.

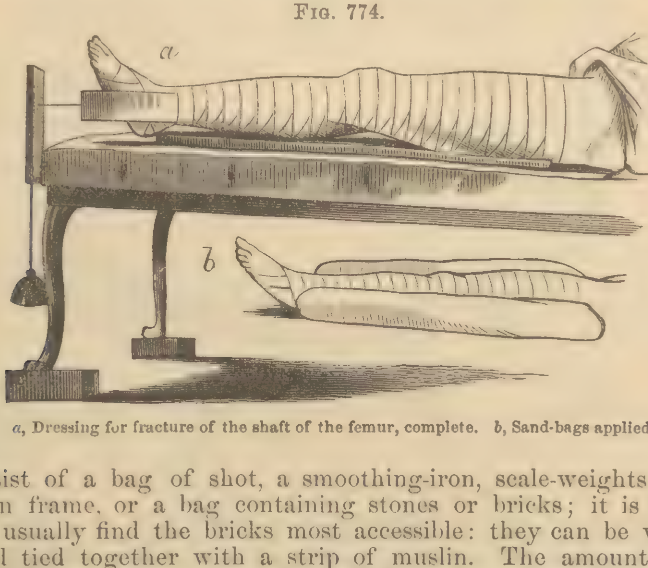
Application of the dressing.—The patient being placed upon the bed, the hair should be removed from the limb, and the skin thoroughly cleansed with soap and water, and well dried, so as to secure the adhesion of the plasters. The extension-bands are next warmed by passing the back of the strips over a tin vessel containing hot water, or over a flat-iron or a stove-pipe, or by holding them before an open fire, and are then immediately placed along the outer and inner surfaces of the leg and thigh, taking care that they cover exactly corresponding portions of the limb, so that the stirrup will draw equally on the two sides. Next take the circular strips and pass them about the leg and thigh, as shown in Fig. 773. The surgeon has now reached a stage in the dressing when the fracture is to be carefully adjusted by extension, counter-extension, and manipulation. If the patient complains of severe pain, or if much muscular resistance is encountered, it will be best to administer an anæsthetic, after which an assistant, grasping the ankle, should bring the limb down to its proper length. The extension being now kept up, the surgeon proceeds to apply a roller, with firmness, from the ankle to the groin. This should never be neglected. If done properly, the muscles remain quiet under its pressure, and spasms, with displacement, seldom occur. The cord from the stirrup is next to be tied about the upright post, the lower end of the bed being raised four or five inches by placing blocks beneath its feet, and the sand-bags laid along the inner and outer sides of the limb. After the lapse of six or eight hours, the extending weight may be attached; if done sooner than this, the plasters will certainly slip. To make this attachment, bring the ends of the muslin strip or the cord which is fastened to the stirrup over the pulley, and to its end attach the requisite weight. (Fig. 774.) This

Fig. 773.



Extension apparatus applied to the limb.

Fig. 774.



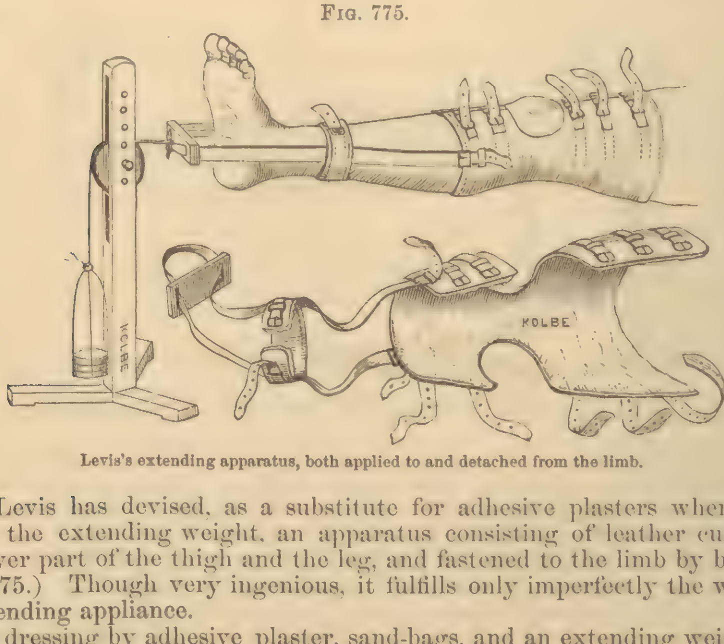
a, Dressing for fracture of the shaft of the femur, complete. *b*, Sand-bags applied.

may consist of a bag of shot, a smoothing-iron, scale-weights supported in an iron frame, or a bag containing stones or bricks; it is immaterial what. I usually find the bricks most accessible: they can be wrapped in paper and tied together with a strip of muslin. The amount of weight which will be necessary in an adult will be two or three bricks, or about ten or fifteen pounds. It has been my practice to begin with two bricks, or ten pounds, and after two or three days to add a third, or even more, until the measurements of the two limbs correspond. This comparison

should be made daily until the proper length is obtained. To make our mensuration trustworthy, the patient must be on the back, with the body inclined neither to the right nor to the left, with the crests of the ilia on the same level, and with the muscles of the limb entirely quiescent. The tape used should be the metallic one, and the points between which these measurements should be made are the anterior superior spinous processes of the ilia, the tuberosities of the pubic bones, and the umbilicus above, and the lower extremities of the inner malleoli below. By measuring consecutively from these three stand-points, a very accurate result may be obtained.

The weight which to-day fails to bring the limb to its proper length may have the desired effect to-morrow. The muscles may for a time resolutely hold out, but the steady, uninterrupted pull, night and day, will finally gain the victory, not by violence, but rather by gentle constraint. The angle at which the extending cord runs from the stirrup to the pulley should be graduated so as to allow the heel barely to touch the bed, or even so as to clear it entirely. It is seldom necessary to renew the adhesive plasters more than once; and very frequently I have found the first application answer for the entire period of treatment. The roller is liable to become displaced after eight or ten days, and should be replaced or tightened, at which time the extension must be kept up by the hands of an assistant, who at the same time will raise the leg sufficiently high to allow the roller to pass readily. During the time of treatment, which usually occupies from seven to eight weeks, the patient must not be allowed to raise his body up in bed, nor should more than a single pillow be placed under his head. After the lapse of four or five weeks, if the union progresses favorably, the weight attached to the foot may be lessened. At the expiration of seven or eight weeks, the patient may be allowed to rise from his bed and move about with crutches, but he must not rest the weight of the body upon the limb to any extent for at least three or four weeks longer. The urine must be passed in a urinal, bottle, or cup, and the diet, except perhaps during the first two or three days, need not be different from that used in health. The mode of changing the sheets and linen has been described on page 734, and need not be detailed in this place.

FIG. 775.



Levis's extending apparatus, both applied to and detached from the limb.

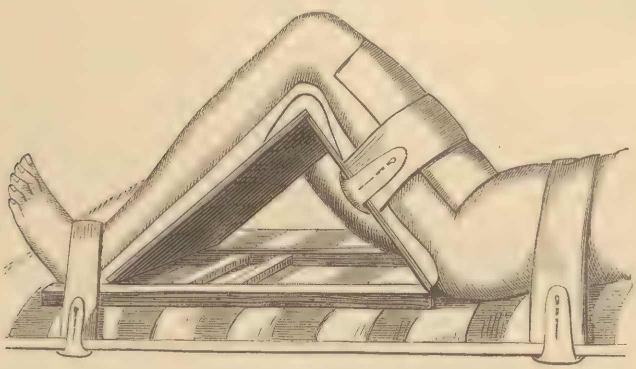
Dr. Levis has devised, as a substitute for adhesive plasters whereby to attach the extending weight, an apparatus consisting of leather cut to fit the lower part of the thigh and the leg, and fastened to the limb by buckles. (Fig. 775.) Though very ingenious, it fulfills only imperfectly the work of an extending appliance.

The dressing by adhesive plaster, sand-bags, and an extending weight re-

duces the treatment of most fractures of the thigh to the simplest form, indeed, so nearly approaches perfection that little else can be desired, and is equally well adapted to cases in which both thighs are broken.

When the fracture is a short distance below the trochanters, or in some part of the upper third of the bone, a difficulty may be experienced in consequence of the anterior projection of the short upper fragment. In such a case the thigh must be first flexed on the pelvis, and then extension applied, during which a concave anterior splint is to be placed upon the front of the thigh, and bound firmly with a roller. The limb should now be brought quietly into the straight position, and, if the deformity is corrected, the usual dressing for fractures of the shaft may be prepared and applied. If the displacement cannot be thus corrected, there remain but two methods for our adoption,—either the double inclined plane or the wire anterior splint of Nathan R. Smith. Very little extension can be made by either mechanism, and considerable shortening must be expected. If the double inclined plane be selected, a soft cushion or pillow must be interposed between the limb and the splint, and a piece of binders' board moulded to the front of the thigh. A few turns of a roller applied some distance above the knee, and also above the ankle, will serve to secure the limb to the splint. (Fig. 776.) Another

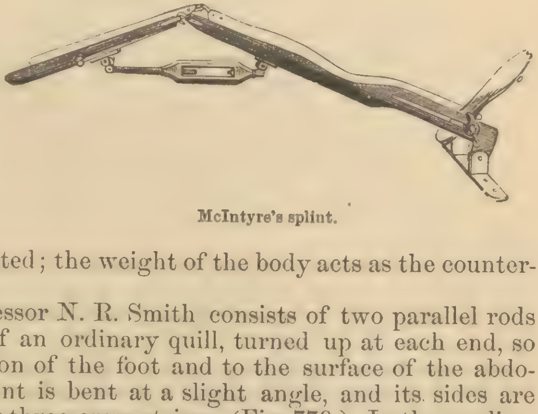
FIG. 776.



A fracture at the upper third of the femur dressed on a double inclined plane.—Smith.

apparatus used for the same purpose is that of McIntyre (Fig. 777), which can be adjusted to any angle by means of a posterior screw. In applying this apparatus, the thigh and leg piece must be well padded or covered with a cushion, and set at an angle of about thirty-five degrees. The limb being now placed upon the splint and the foot made fast to the foot-board by means of a bandage, the screw should be turned until the inclination at the knee is considerably increased, by which the extension is augmented; the weight of the body acts as the counter-extending force. (Fig. 778.)

FIG. 777.

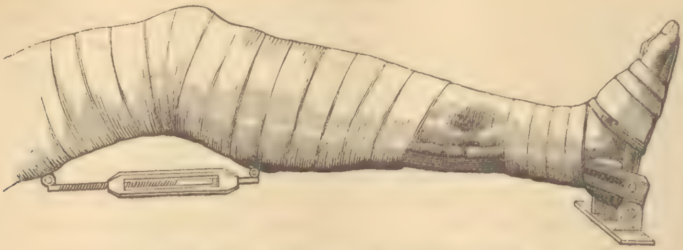


McIntyre's splint.

The anterior splint of Professor N. R. Smith consists of two parallel rods of wire about the thickness of an ordinary quill, turned up at each end, so as to correspond to the direction of the foot and to the surface of the abdomen. At the middle, the splint is bent at a slight angle, and its sides are kept from separating by two or three cross-strips. (Fig. 779.) In the application of this splint, a double inclined plane of pillows must be first constructed

on the bed, and across it are to be laid strips of muslin, two and a half or three inches wide and twelve or fourteen inches long. These strips require to be

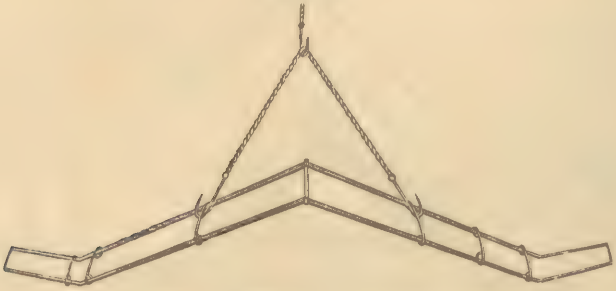
FIG. 778.



The McIntyre spint applied, as modified by Liston.

three inches apart, and to increase in length as they ascend the limb. Upon those strips which correspond to the thigh should be laid a light board splint, three inches wide and about nine inches long, well padded. Let the limb of the patient be now placed on this part of the dressing and the wire splint

FIG. 779.



Professor N. R. Smith's anterior wire splint.

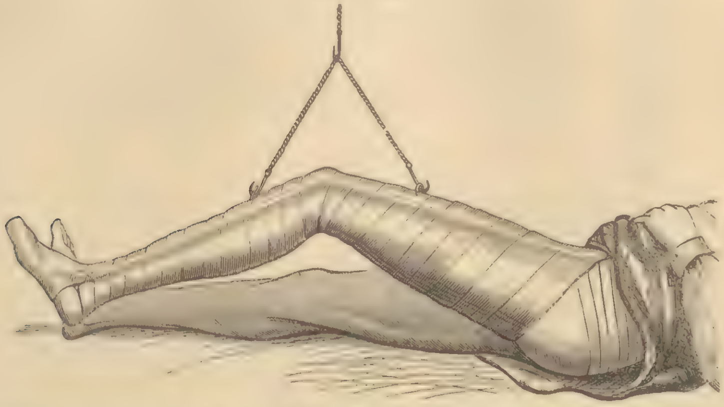
be bent so as to conform to such an angle of the limb as will be required to effect the adjustment of the fragments; for in the case presumed to be now under treatment, the lower fragment must be brought forward to the displaced upper one. The next stage of the dressing is to bring the muslin strips up along the sides of the limb, and, turning their ends around the wire, pin each end to its own side. They should be secured sufficiently loose to allow the splint to be raised a very little from the surface of the limb. The apparatus being now suspended by the cord running obliquely forward, and the limb being raised clear of the bed, additional security should be given to the dressing by a roller carried around the splint and limb, from the foot to the pelvis, and terminating by making a spica of the groin. (Fig. 780.) Dr. Hodgden, of St. Louis, uses occasionally a similar splint having a cotton sacking loosely extended between the bars, upon which the limb is supported. The suspension can be effected from a hook and pulley fixed in the ceiling of the room, or from a cross-bar over the bed, with a pulley attached.

An arrangement for this purpose, very familiar to Philadelphia surgeons, is a gallows, which rests upon the sides of the bed, and admirably answers the purpose. This arrangement is figured under the head of "Fractures of the Leg."

In the fall of 1870 I treated a very perplexing case of fracture at the upper third of the femur, in a gentleman of this city, by a combination of the inclined plane and extension by adhesive straps, which resulted so favorably that I regard the plan as preferable to all others. In several points it

is not unlike that of Dr. Palmer, of the United States Navy. The apparatus which I employ consists of a double inclined plane, with hinged sides attached to the thigh-piece. Upon this the limb is deposited, a pillow being interposed between the thigh and the splint, and a soft pad placed beneath the

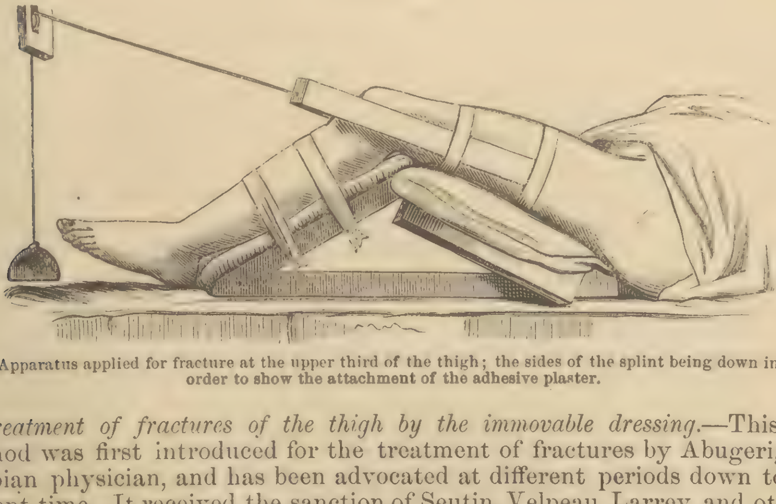
Fig. 780.



Limb suspended by the anterior splint of N. R. Smith for fracture at the upper third of the thigh. The suspending cord should be fixed to a point some distance above the foot.

leg. An adhesive strip is next attached to the sides of the thigh, extending up as far as the upper end of the lower fragment, and with a loop below, into which is to be fastened a piece of light wood, as in the ordinary fracture dressing already described. To this piece of wood a cord is attached, which is to be carried over a pulley set in an upright that is screwed to the foot of the bed. To this cord the extending weights are to be attached. Lateral pressure is applied to the thigh by bringing up the sides of the femoral part of the plane and securing them by strips of muslin while the leg is retained in position by the turns of a roller. (Fig. 781.)

Fig. 781.



Apparatus applied for fracture at the upper third of the thigh; the sides of the splint being down in order to show the attachment of the adhesive plaster.

Treatment of fractures of the thigh by the immovable dressing.—This old method was first introduced for the treatment of fractures by Abugerig, an Arabian physician, and has been advocated at different periods down to the present time. It received the sanction of Seutin, Velpeau, Larrey, and others. It has been a favorite dressing for fractures of the thigh at the Bellevue Hospital, New York, plaster of Paris being the material used to give immobility to the enveloping bands. It is applied as follows:

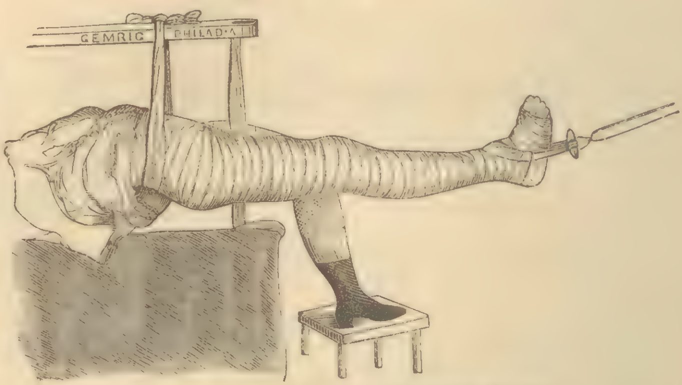
On a mattress, raised one foot from a table, and reaching within two feet

of its lower end, the patient is placed. An upright (Fig. 782) is screwed against the lower corner of the table, and surrounded with a soft wrapping to protect the perineum from pressure. The patient is brought down, with one limb on either side of the stanchion, so that the nates project beyond the mattress, where they are supported by a sling, which is made fast to a piece of timber running back horizontally from the upright. (Fig. 783.) The patient being now etherized, a pulley is attached to the foot and ankle and the leg drawn to its proper length. The extension must be in a line with the axis of the body. The rollers, filled with plaster in the

Fig. 782.

Upright or stanchion.

Fig. 783.



Making extension for the plaster dressing.—After Hamilton.

manner described under the head of fracture dressings, are next applied to the limb and the pelvis, both previously covered with a thin woolen cloth. Four or five of these in succession, with pieces of flannel filled with plaster interposed here and there, serve to supply the necessary resistance. The extension is maintained for fifteen or twenty minutes after the dressing is applied, or, in other words, until the plaster is firmly set, when the patient is placed in bed. On the second or third day he is permitted to move about on crutches. Generally the dressing is applied to the foot and leg one or two hours before the etherization and reduction, so that the extension may be applied over the bandage after it has fully hardened. It is claimed for this mode of treatment that a cure is accomplished with little if any shortening, and that the patient is not confined to his bed after the first two or three days. Where patients can be kept under constant supervision, I have no doubt very satisfactory results may be obtained. It cannot be denied, however, that there are certain objections against the plan which are entitled to serious consideration. First, the limb is entirely concealed from inspection, and the surgeon consequently is unable to determine the state of the parts; secondly, the dressing may become so tight from subsequent swelling as to produce gangrene; thirdly, the limb may, after the subsidence of the swelling, lie so loose in its shell that, from the want of proper support, the bone may fail to unite. If such accidents occur, as they have occurred even in the hands of those familiar with the application of the plaster appareil, it would be obviously improper to inculcate the general application of this dressing.

Fractures near to and at the Condyles of the Femur.

The grave character of these injuries is due to their proximity to a large joint. These fractures may run across the base of the condyles, separating them from the shaft; they may pass through one condyle, separating it from its fellow, or only detaching a portion of its mass; they may run between

the condyles, either vertically or obliquely, and be conjoined with a fracture through the lower third of the shaft; or there may be a separation of the epiphysis of the condyles.

Fractures through the Base of the Condyles.—These may follow force applied either directly or indirectly. The line of fracture is commonly oblique, running downward and forward. (Fig. 784.) With few exceptions, the upper fragment will be found in front of the lower; sometimes it is lodged between the condyles and the patella. (Fig. 785.) It has been known to

Fig. 784.

Oblique fracture immediately above the condyles of the femur.—Malgaigne.

Fig. 785.

Upper fragment in front of the condyles of the femur.

Fig. 786.

Impacted fracture above the condyles of the femur.

pierce the quadriceps muscle, and even to tear the capsule of the joint. In some instances it has been driven into the cancellated tissue of the condyles, constituting an impacted fracture. (Fig. 786.)

Again, the upper fragment may pass behind the lower one; though this is a very rare occurrence. Hamilton has seen two cases, and in the Marsh collection of pathological bones at Albany is a specimen illustrating a similar disposition of the broken ends. The blood-vessels of the popliteal region are, under such circumstances, exposed to damage from pressure. This has been noted by Amesbury, Lonsdale, and others; and it is quite probable that the sloughing of the foot which followed a case of fracture at the lower end of the femur, under the care of a surgeon at Lockport, New York,* and which resulted in a suit for damages, was due to such pressure.

The swelling which rapidly supervenes after an injury of this kind may mask the true nature of the case for a time, but by making firm and continuous lateral pressure for several minutes the extravasation may be displaced, and the condyles at last reached, when their mobility on pressure, without affecting the shaft of the bone above, will sufficiently declare the nature of the case. Should the joint be involved, the injury is liable to be followed by an acute synovitis, terminating in anchylosis, or in a destructive suppuration, from which the patient may at last die. Even when the articulation has received no damage, the inflammation around may gradually creep into the joint, leaving it chronically enlarged and with more or less stiffness.

The reduction is best effected by flexing the leg upon the thigh, at the same time making extension with the forearm in the popliteal space, as in certain fractures of the lower third of the femur, to which allusion has already been made. It is important in all attempts to effect reposition of

* Hamilton on Fractures, p. 388.

the fragments that no careless or aimless movements be practiced, lest the joint receive injury at the hands of the surgeon. When the adjustment has been accomplished, should the direction of the fracture be not too oblique, there will be little tendency to a renewal of the displacement, as the voluminous dimensions of the bone at this point offer broad surfaces for the support of the fragments.

TREATMENT.—After adjustment, the limb should be placed in the extended position and the same dressing applied as for fractures in the middle third of the shaft,—namely, adhesive strips, weights, and sand-bags. The strips must not extend above the knee. The ham should be supported by introducing between the knee and the bed a compress of soft flannel. Special care must be observed to keep the sand-bags in close contact with the limb, in order to prevent lateral movement.

Fractures of one Condyle.—Fracture of one condyle (Fig. 787) is much more rare than that of both, although neither can be considered common. Malgaigne has seen but three cases. Packard has collected seven additional ones.* These, with one seen by Sir Astley Cooper, one recorded by M. P. Boyer, one in the Dupuytren Museum, one by Dr. Lewis Riggs, reported to Hamilton,† and one in my own cabinet, making in all fifteen cases, constitute all the fractures of this kind known to me. A curious feature connected with one of these cases, that of Dr. Crosby,‡ was the failure of the fragment to unite, and its removal six months afterwards, through an incision made for that purpose. The operation was followed by a complete recovery.

FIG. 787.

Fracture of the external condyle.

Fractures of both Condyles.—In this injury the lines of fracture run both vertically and transversely,—the former between the condyles, and the latter separating them from the shaft of the bone. Professor Gross has in his cabinet a specimen quite unique, in which both condyles are broken off, leaving the trochlear surface connected with the shaft. Several specimens of fracture of both condyles are in the Gibson collection of bones, now in the possession of the United States Government. There is a specimen of this injury in the museum of the University of Pennsylvania, and one in my own collection.

CAUSES.—These fractures are produced most commonly by direct force, as by a fall upon the knee, or by the articulation being caught between the buffers of cars.

Professor Volkmann, of Halle, describes another injury sustained by the condyles of the femur,—that of having a portion of the articular cartilage with a scale of the subjacent bone torn off. The accident is said to occur from a fall on the knee during flexion of the limb. In the case of Professor Volkmann,§ the detached piece was extracted from the joint after the manner of removing false cartilages, the limb was placed in a plaster dressing, and the recovery was complete.

Mr. Teale, surgeon to the Leeds General Infirmary, describes a similar case, produced by a cask slipping against the knee of a laborer. The removal of the piece was followed by phlegmonous erysipelas and death.‖

Brodhurst has met with several cases.¶ It is very probable that the detachment does not always occur immediately on the reception of the injury, but subsequently, by exfoliation.

When diastasis of the epiphysis takes place, the separation is not always

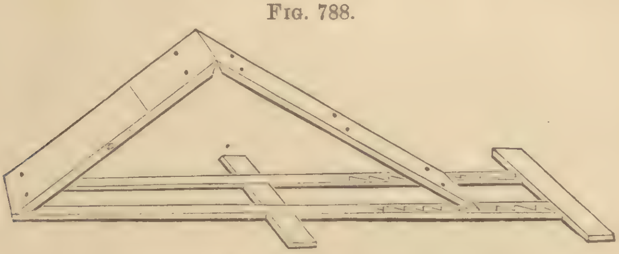
* Malgaigne on Fractures, Packard's trans., p. 593.
† Hamilton on Fractures, etc., p. 429.
‡ New Hampshire Journal of Medicine, 1857.
§ Deutsche Klinik, 1867, p. 448.
‖ Medico-Chirurgical Transactions, vol. xxxix. p. 31.
¶ St. George's Hospital Reports, vol. xi. p. 141.

confined to the underlying cartilage, but may extend into the diaphysis, as was shown in Dr. Little's case.

TREATMENT.—The patient being etherized, the limb should be flexed and the displaced bone forced by pressure and counter-pressure into position, after which the limb may be placed either over a double inclined plane or in a long, straight fracture-box.

History of the Treatment of Fractures of the Thigh.—The simplicity of our present methods for the treatment of fractures of the thigh conveys a very imperfect idea of the time and ingenuity expended and the multiform mechanisms which have been invented and modified in reaching our present state of knowledge. A rapid review of the subject, in a general way, will not be without interest to the student who desires to follow the progress of medical thought. Two positions—the extended and the semi-flexed—have each had their advocates at different periods. The first, or extended one, is the most ancient, dating back to Hippocrates, and the one at present adopted by the great majority of surgeons in America, Great Britain, and on the Continent. The semi-flexed or physiological position was introduced by Pott, the patient being at the same time placed on the side. With certain modifications, the plan of this distinguished surgeon was

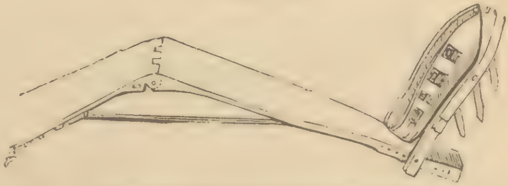
FIG. 788.



Double inclined plane of Bell, properly James's.

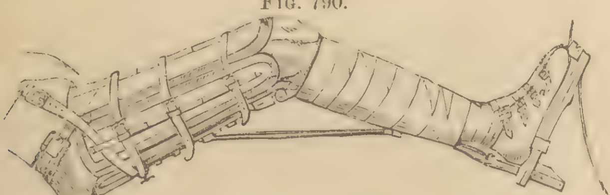
adopted in Great Britain by Sir Astley Cooper, the two Bells, Earle, Amesbury, and others. The position was changed to the back instead of the side, and the semi-flexion maintained by a double inclined plane, first used by White, of Manchester, and afterwards modified by James, Bell, Amesbury, and McIntyre, such as are seen in Figs. 788, 789, 790. On the Continent, Dupuytren became its champion, and the influence of his great name secured for it the favorable opinion of many of his professional countrymen. Desault and Boyer, however, resolutely

FIG. 789.



Amesbury's double inclined plane splint.

FIG. 790.



Amesbury's splint applied.

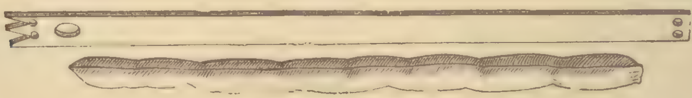
planted themselves against this formidable array of professional power, and eventually brought about a careful reconsideration of the subject, and, as a

consequence, such a reaction that at present few surgeons of any prominence can be found, either in America or abroad, who advocate the semi-flexed position, except in certain fractures in the upper third of the shaft, where it often becomes imperative.

The objections to the semi-flexed position are the following. 1. It only removes muscular resistance on one aspect of the limb:—for example, when applied to the thigh, the hamstring muscles alone are relaxed, whilst the individual muscles forming the quadriceps are made tense, and these, from their great power, are the chief displacing agents. 2. The inherent tendency in a muscle to shorten when relaxed, only shows that after a time this state of relaxation is changed to one of tension, which will then contribute to the overlapping. How quickly the biceps flexor cubiti becomes shortened when the forearm is flexed for a short time at a right angle with the arm!

By the plan of extension, however, not only are the resistance and spasm of the muscles overcome by the action of a constant force, but the muscles themselves are lengthened by a modified nutrition, so that both longitudinal and angular deformity are reduced to their least possible quantities. To make effective the principles of extension and its equivalent counter-extension, numerous plans have been attempted. As far back as Avicenna, and in later times by Petit and Heister, these indications were carried out by bands extending from the upper part of the thigh to the head of the bed, and from the ankle to the foot of the bed. To avoid the inconveniences of pressure, Petit fastened one of his extending bands above the knee and the other to the ankle, thus alternating the traction. Others employed the cord and weight running over a pulley at the foot of the bed; but this was abandoned because the body was drawn down by the extending force. The methods of Desault, of Boyer, and of Liston were next introduced. In each of these, extension and counter-extension were made by a long external splint extending from the crest of the ilium to a point four inches below the foot. A soft leather band, well stuffed, was passed about the perineum and made fast to the upper end of the splint, by which counter-extension was made. An extending band was placed about the ankle and foot, and secured to the lower part of the splint, whereby extension was effected, and by means of cushions or junk-bags interposed between the limb and the splint

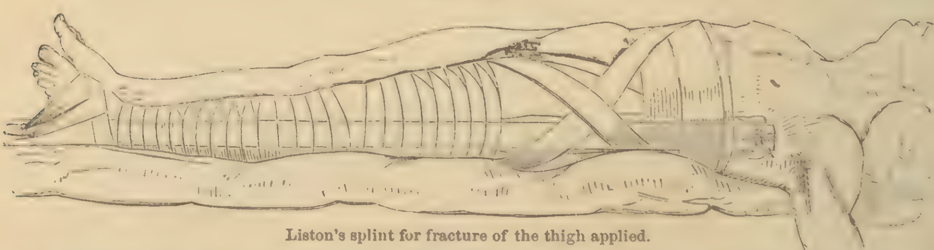
FIG. 791.



Liston's splint and junk-bag.

the parts were protected from undue pressure. The points of difference between these three mechanisms were as follows. In Liston's, the foot was secured to the processes (Fig. 791) at the lower end of the splint by

FIG. 792.



Liston's splint for fracture of the thigh applied.

a roller passing from one to the other, and then junk-bag, splint, and thigh were all bound together by continuing the roller up the limb. (Fig. 792.)

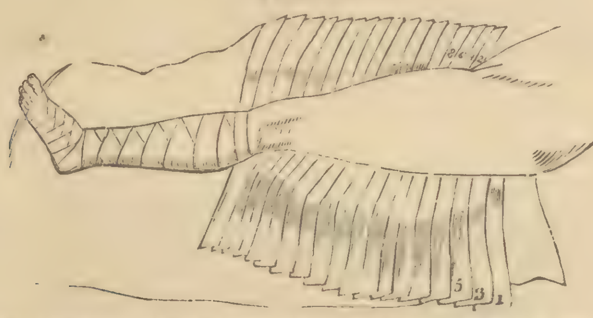
In Boyer's apparatus, the long splint had a foot-board, which was moved up and down by means of a screw, for the purpose of making extension, an inside splint extending from the perineum to the foot, and an anterior one reaching from the groin to the ankle: the inner and outer splints were enveloped in a splint-cloth. Counter-extension was made by a padded leather band passing through the perineum and buckled into the upper end of the outer splint, while extension was accomplished by a gaiter attached to the ankle and instep. Cushions were placed between the splints and the limb, and both were secured together by tapes passing round the extremity. (Fig. 793.) Desault's apparatus differed from both: from Liston's, in having an in-

FIG. 793.

Boyer's splint for fracture of the thigh applied.

side splint, and in using tapes instead of a roller to secure the dressing; and from Boyer's, in having no movable foot-board. It consisted of an outside splint, long enough to extend from the crest of the ilium to a point four inches below the foot; and of a second, reaching from the perineum to the sole of the foot. A hole was made in the upper and one in the lower end of the long splint, the first for the counter-extending and the second for the extending band. A third splint was placed over the anterior surface of the thigh, which, together with junk-bags and the Scultetus bandage, completed the apparatus.

FIG. 794.



Application of the Scultetus bandage previous to applying the splints after the Desault method.

The defect of this appliance (Figs. 794, 795) consists in the direction at which both the counter-extending and extending forces operate, which favors a lateral displacement of the fracture. The excoriation and ulceration which were

FIG. 795.

Desault's apparatus for fracture of the thigh applied. Counter-extending band not shown.

often produced by the extending and counter-extending bands constituted another serious objection. Maintaining as this apparatus did for so long a

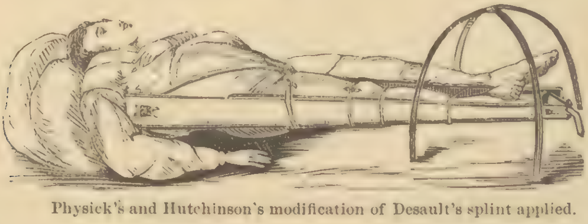
time the confidence of the profession, and being still used in many localities through the country, it will not be amiss to give a brief notice of the changes which it has undergone. As it came from the hand of its author, it was an imperfect apparatus. Physick, in order to secure counter-extension more in the line of the body, and to prevent lateral inclination of the pelvis, neither of which was secured by the Boyer dressing, had the outer splint carried up to the axilla; while Hutchinson, that the extension might be made in the long axis of the limb, devised the block which is now nailed a short distance above the lower end of the long splint. (Fig. 796.) As thus modified, the dressing

Fig. 796.

Hutchinson's modification of Physick's splint.

is applied in the following manner. The bed being prepared, several pieces of bandage or strong tapes are laid down; over these is to be spread the splint-cloth,—namely, a piece of unbleached muslin one yard wide, and long enough to extend from the perineum to the foot. To the foot and ankle is next attached the gaiter for the extending bands, and through the perineum is passed a well-stuffed counter-extending band. The splints are now rolled in the splint-cloth almost to the outer and inner surfaces of the limb, leaving barely sufficient room for the interposition of the junk-bags; after which the perineal band must be fastened into the hole at the upper end of the long splint, and the extending bands carried round the block below. The limb being then extended to the proper length, the lower band is carried through the opening at the lower end of the splint and secured by a knot. Finally, the strips of bandage are to be tied securely around the splints and the limb, holding both firmly together, and to sustain the weight of the bed-clothes a cradle or hoop should be placed across the leg and foot. (Fig. 797.)

Fig. 797.



Physick's and Hutchinson's modification of Desault's splint applied.

Dr. H. Lenox Hodge, in order to dispense altogether with the perineal counter-extending band, and to prevent the patient from rising or sitting up during the treatment, attached to the long splint a piece of iron which extends over the front of the patient's shoulder and terminates in a blunt hook. (Fig. 798.) The counter-extension is made by a broad piece of adhesive plaster placed on the front and back of the chest, and secured by strips carried around the body, the loop of the longitudinal strip being attached to the hook at the end of the metal bar. (Fig. 799.)

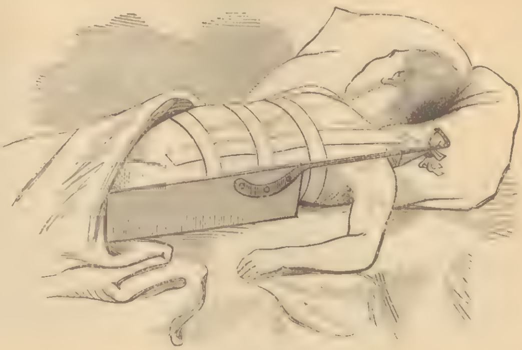
Fig. 798.

Hodge's attachment to the long splint.

Various other methods have been devised to effect counter-extension. Thus,

we have Dr. Joseph Hartshorne's splint (Figs. 800, 801), in which counter-extension is made against the perineum at the upper end of the inside splint, and extension by a movable foot-board worked by a screw. By this arrangement the outer splint can be detached from the inner one without disturbing either the extending or the counter-extending force.

Fig. 799.

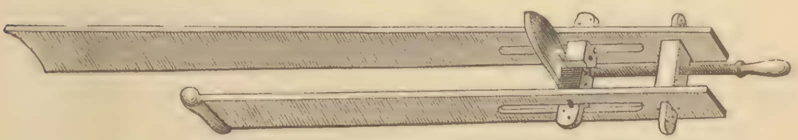


Hodge's splint applied.

Brunninghausen made the broken thigh fast to the sound one, forgetting that the control of the lateral movements of the pelvis was as necessary as to fix the thigh.

Hagedorn's apparatus—which consisted of two splints adjusted to the outside of the thighs, with a movable foot-board to which both feet were secured—was open to the same objection as was the arrangement of Brunninghausen. This defect

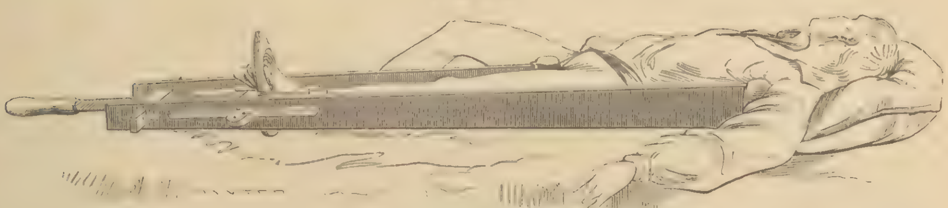
Fig. 800.



Hartshorne's splint.

was measurably obviated by Gibson's modification, by which the splints were carried up to the axillæ.

Fig. 801.



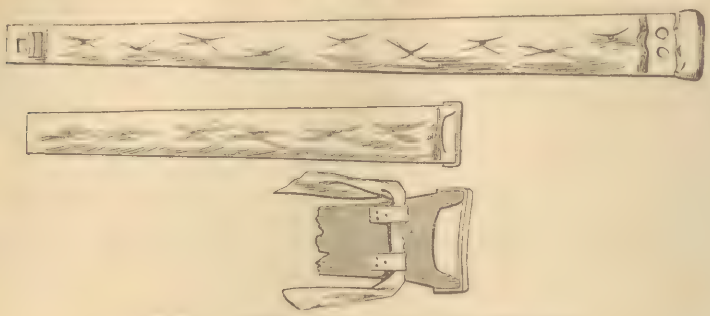
Hartshorne's splint applied to the patient.

Professor William E. Horner used a modification of Desault's splint. The long and short splints were padded, in order to dispense with the junk-bags; a strip of leather was stretched across the upper end of the inside splint, and on the outer surface, near its upper extremity, two strong leather loops were nailed for the passage of the counter-extending band (Fig. 802), the ends of the latter being tied to the upper extremity of the long splint. Both splints, by this arrangement, were employed in making counter-extension. (Fig. 803.) Extension was accomplished by adhesive strips.

Professor John Neill, by attaching a double cord to the extending and counter-extending bands, and bringing the ends over the upper and lower extremities of the outside splint, made extension and counter-extension at the same moment by twisting the rope after the manner of the Spanish windlass.

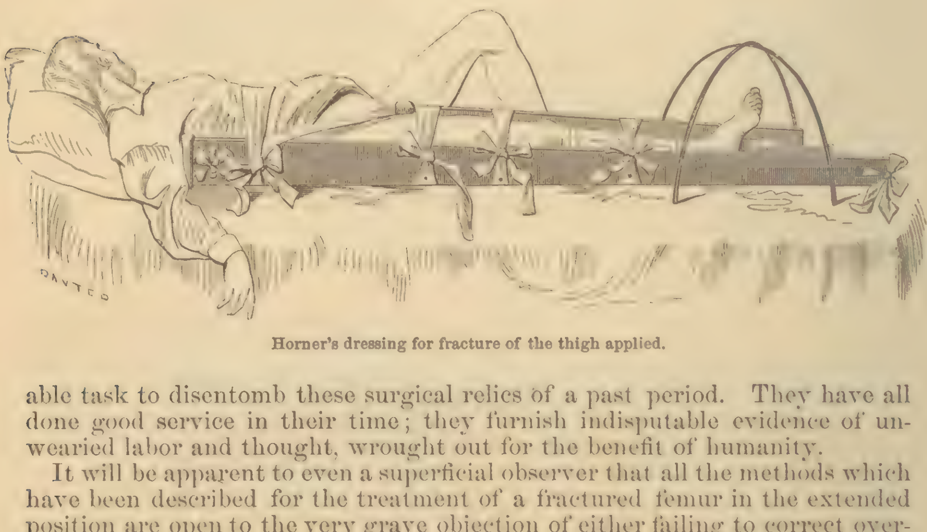
Professor Gross has used for many years a long fracture-box, with a fenestrated foot-piece and two crutches, one for the axilla and one for the perineum. Many others might be enumerated, such as Gilbert's, Sanborn's, Hodgen's, Flagg's, Lente's, Burge's, Dugas's, etc.; but it would be an unprofitable task to disentomb these surgical relics of a past period. They have all done good service in their time; they furnish indisputable evidence of unwearied labor and thought, wrought out for the benefit of humanity.

FIG. 802.



Horner's modification of Physick's and Desault's splint.

FIG. 803.



Horner's dressing for fracture of the thigh applied.

It will be apparent to even a superficial observer that all the methods which have been described for the treatment of a fractured femur in the extended position are open to the very grave objection of either failing to correct overlapping of the fragments or of having a strong tendency to produce excoriations, ulcerations, and even sloughing of the soft tissues over the perineum and about the ankle, the parts where the counter-extending and extending bands must act.

To obviate these serious inconveniences was unquestionably the great desideratum in the treatment of fractures of the thigh; and this has been satisfactorily accomplished through the ingenuity of American surgeons. The first of these improvements consists in connecting to the limb the extending weight or power by means of adhesive plaster.

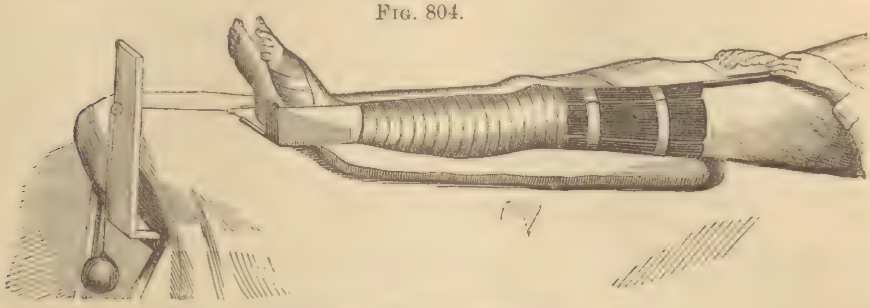
Adhesive plaster was probably first used as a means of making extension in the treatment of fractures by Dr. Joseph Swift, of Easton, Pennsylvania, and the attention of the profession was invited to it by Professor Gross as early as 1830.

In 1843, Dr. E. Wallace, then a resident physician in the Pennsylvania Hospital, at the suggestion of Dr. Ennis, of Easton, employed this dressing

with entire success in a very troublesome case of fracture of the femur.* Dr. Ennis stated that his knowledge of this plan of applying extension was derived from a fellow-townsman,—Dr. Swift.

Dr. David Gilbert was also at a very early period in the habit of using this material for the same purpose. The credit of originating this method of extension has likewise been ascribed to Dr. Crosby, of Manchester, Vermont. About the year 1852, Dr. Buck, of New York, introduced this plan of treating fractures of the thigh into the New York Hospital (Fig. 804), and

Fig. 804.



Dr. Gurdon Buck's dressing applied.

through the influence of this distinguished gentleman the adhesive plaster dressing soon acquired a very general popularity with the profession.

The pulley and weight by which the extension is applied to a broken limb cannot, however, be considered as a modern discovery. Hamilton says that Howe, of Boston, as early as 1824, recommended the use of such appliances; and this, if correct, would antedate the claim for priority in this matter made for Mr. Janney, of Exeter, England. Similar mechanical measures were employed by Daniel,† and by Dugas, of Georgia.‡ Boyer speaks of the weight and pulley being a very ancient contrivance, and a similar statement is made by Malgaigne,§ who says that both were known to Guy de Chauliac and to Seutin.

The addition of an elastic substance, like india-rubber, for the purpose of extension and as an accumulator of power, is also an American improvement, having originated with Dr. Davis in 1856, from whom Dr. Buck states that he received the idea.

The second great improvement consisted in dispensing with the counter-extending bands. Professor Gibson introduced a plan of treating fractures of the thigh upon a single inclined plane, by which the perineal bands were rendered unnecessary (Fig. 805); but a more simple method is that now generally practiced, of raising the foot of the bed, by which the weight of the patient's body becomes the opposing force to the extension. This device was first suggested by Dr. Van Ingen, of Schenectady.||

Fig. 805.

Gibson's single inclined plane for fractured thigh.

* Pennsylvania Hospital Reports, Dr. Hunt's paper, 1869.
† American Journal of the Medical Sciences, 1829, vol. iv. p. 330.
‡ Southern Medical and Surgical Journal, February, 1854.
§ Treatise on Fractures, Packard's trans., p. 197.
|| Transactions of the American Medical Association, vol. x. p. 436, New York, 1857; Van Buren, New York Medical Record, March 30, 1878.

The last improvement consisted in abandoning the old plan of supplying lateral pressure by the long and short splints, and substituting for this purpose bags filled with sand. The practice originated with an American army surgeon, and was introduced into the Pennsylvania Hospital by Dr. Hunt, in 1863, and about the same time was commenced in the New York Hospital.

Fractures of the Femur in Children.

It is proper that some distinct notice should be given to the treatment of fractures which occur in the femora of children under ten years of age. In children over that age, I have usually employed the same apparatus as that used for similar accidents in the adult, namely, the adhesive strips, the pulley, the weight, and the sand-bags. I have met with this fracture in an infant of four weeks in whom it was produced by a nurse falling from the step of a carriage and at the same time pressing the child closely to her breast in order to defend it from injury.

The frequency of these fractures is quite remarkable. Of 885 fractures of the thigh treated in the Pennsylvania Hospital, 152 were in children under ten years of age. Of 140 recorded at the Hôpital Sainte-Eugénie in a single year, 26 occurred in the femora of children.*

The injury is limited to the shaft, or to the epiphysis. These fractures, when properly treated, are rarely followed by any appreciable shortening, and heal in nearly one-half the time required for the cure of a like lesion in an adult. There are several reasons for the absence of deformity. First, these fractures are often incomplete, many of the fibres of the bone maintaining their continuity in consequence of the elastic nature of their structure; secondly, the line of fracture is generally more transverse than in adults, so that when once the fragments are adjusted there is little tendency to displacement; thirdly, the muscles at this age are not capable of exercising much power, and hence the employment of any great amount of extending and counter-extending forces becomes unnecessary.

Treatment.—The materials requisite for the dressing are a straight splint, well padded and sufficiently long to extend from near the axilla to two inches below the foot, two plaster rollers, two plain rollers, and a little cotton.

In order to avoid all struggling, muscular resistance, and pain, an anæsthetic should be first administered to the child. The limb is then to be drawn down to its proper length, the fragments adjusted, and the extremity covered in with one of the plain rollers, terminating with a spica of the groin. Placing a little cotton at the external surface of the ankle, the knee, and the crest of the ilium, the long splint is next to be laid along the outer side of the body and the limb, and bound in position by the plaster rollers, commencing at the foot and ending with a spica of the groin. During the application of the rollers, and until they become set, extension must be kept up. The dressing is completed by securing the upper part of the splint to the trunk with the remaining plain roller,—a very important feature of the apparatus, as by so doing the little patient is rendered incapable of sitting up. (Fig. 806.) If plaster cannot be obtained, the silicate of soda, or even starch, may be used to give resistance to the rollers.

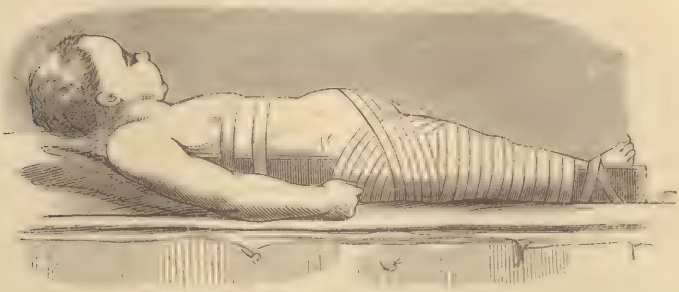
When the silicate of soda is used, three or four strips of pasteboard covered with the liquid should be laid about the seat of fracture, and a third roller applied to the entire limb, receiving in turn its due portion of the liquid glass. The lower end of the bed should now be raised, and the foot made fast to the foot-board below until the dressing becomes firm, which will require usually from twelve to fourteen hours. The impenetrable nature of the silicate will render the rollers impervious to the discharges of the little patient, and when soiled they can be washed without affecting the permanency of the dressing. I have never known this dressing to become too

* Holmes's System of Surgery,—Surgical Treatment of Children's Diseases, p. 254.

tight in consequence of the swelling; but the possibility of such an occurrence should never be overlooked.

In the event of the bandages becoming too loose, they should be removed

FIG. 806.



Dressing for fracture of the thigh in a child applied.

and replaced by others. A folded sheet or a soft towel must be placed under the nates, to receive the passages from the bowels, and the child, if old enough to comprehend the instructions of the nurse, should be taught to pass the urine into a cup or a bottle. A patient and watchful nurse can, with a little care, soon teach even a very young child to communicate its desires on these points, and thus to co-operate with the attendant in preserving a clean and orderly bed.

Fracture through the Lower Epiphysis of the Femur.—This fracture (Fig. 807) is rarely met with. Hamilton has collected five cases, the oldest patient being fourteen, and the youngest—that mentioned by Madame Lachapelle—being a new-born child, the fracture having been caused by the foot being forcibly pulled upon at the time of delivery. The line of fracture usually leaves the cartilaginous conjunction and passes through a part of the bone. Such was the case in Dr. Little's specimen,* and also in the four specimens of this injury in the museum of St. George's Hospital.†

FIG. 807.

Fracture through the epiphysis of the femur.—Bryant.

The symptoms of this accident are the same as those which follow a fracture at the base of the condyles.

TREATMENT.—The limb should be placed in the extended position, and the ham well supported by a compress of oakum, and covered with an immovable dressing of either the silicate of soda or the plaster roller. Should the position prove incompatible with a proper adjustment of the fragments, it may be changed to a semi-flexed one. The latter posture of the limb is that recommended by Holmes.

Compound and Compound Comminuted Fractures of the Thigh.

These injuries are of the most serious import. By reference to the table on fractures, it will be seen that in the Pennsylvania Hospital, from 1830 to 1850, seventy per cent. of these fractures died, and from 1850 to 1874, fifty-six per cent. The course of treatment will be determined in some measure by the nature of the cause producing the injury. Railroad and gunshot injuries are those which most frequently demand a resort to the knife.

In deciding on the question of amputation, there are four things to be taken into consideration: first, the condition of the bone; second, the con-

* Hamilton on Fractures, etc., p. 460, fifth edition.
† Holmes's System of Surgery, vol. ii.

dition of the soft parts; third, the state of the vessels and nerves; and, fourth, the age and habits of the patient.

With regard to the first, it may be said that it is rarely necessary to remove the limb when the injury is confined to the bone, unless it should be in a case where the comminution is very extensive. Captain Riddle, of Erie, Pennsylvania, was shot in the thigh by a deflected ball from a Creedmoor rifle. The femur was broken into forty pieces. Amputation, under the circumstances, was very properly performed. Instances of such extensive devastation are, however, of rare occurrence. The extension of the fracture into the knee or into the hip-joint would not be a sufficient reason for the use of the knife.

With regard to the injury of the soft parts, the course to be pursued will depend to a great degree on both the nature and the extent of the damage. When the muscles are divided by the ends of the broken bone, or by some sharp body, the case is very much less dangerous than when they are torn, bruised, and pulpified by the external violence, in which case, if the injury is extensive and deep, there will be little prospect of saving the limb.

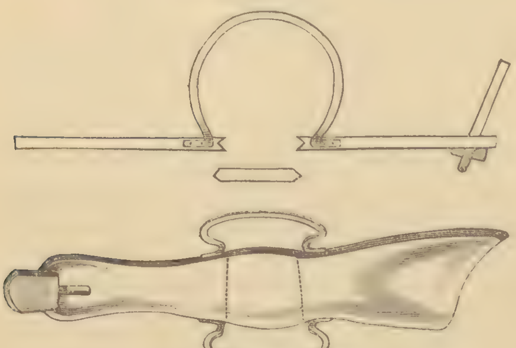
The strictest inquiry should be made into the state of the vessels and of the nerves. If the femoral artery is torn, the extremity will certainly perish, and hence amputation will be demanded at once. The fall of temperature and the absence of the arterial pulse below indicate this lesion. The laceration of the principal nerve will be followed by loss of sensibility and of power in the parts to which it is distributed, but of itself is not a sufficient reason for amputation.

The younger the person, the greater will be the likelihood of recovery; and in doubtful cases it is always wise, when the patient has youth on his side, to abstain from an operation; but if the individual is advanced in life, or one whose system has been deteriorated by bad habits, it will be better to sacrifice the limb at once.

Treatment.—Under the head of remarks on fractures in general, specific directions are given about the management of the external wound, the arrest of hemorrhage, etc., in compound fractures. We need only observe on these subjects that, after the control of the latter, the edges of the wound should be drawn together, and an effort made to convert the fracture into a simple one by entirely excluding the air with an impermeable dressing, never forgetting the possibility—nay, probability—that we will often fail, and therefore that we should watch for the earliest evidences of purulent formations, and at once give them free vent.

Here, as in simple fractures, the extended position is to be preferred, and the extension made in the same manner, though it is probable that the patient will not be able to bear the same degree of traction as in an ordinary fracture. In this particular his feelings must be consulted, so that the weight attached shall not exceed that which is consistent with his comfort. The best disposition of the limb is in a long fracture-box imbedded in bran, than which, as a rule, no more appropriate dressing can be devised. The bran supplies, when packed in between the sides of the box and the limb, an evenly-distributed pressure, absorbs the discharges which flow from the wound, and, when soaked with these discharges, can be removed and its place

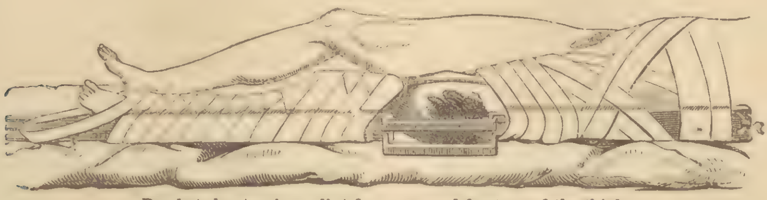
Fig. 808.



Packard's bracketed splint.

supplied with a fresh quantity without subjecting the limb to any disturbance whatever. If the surgeon succeeds in securing the closure of the external wound, of course there is no necessity for the box or the bran, or for deviating from the plan laid down elsewhere for the treatment of an ordinary fracture of the bone. The bracketed splint, in some cases of non-closure of the wound, may be used with advantage. This splint should be constructed so as to permit of the wound being dressed without disturbing the limb. A very good form of this kind of splint, particularly when the injury is about the knee, is that of Dr. Packard (Fig. 808), or the one represented in Fig. 809. Where comminution exists, any loose detached portion of bone should be removed before closing the wound.

FIG. 809.



Bracketed extension splint for compound fracture of the thigh.

Gunshot fractures of the thigh, attended by great comminution of the bone, demand in most cases amputation, especially when the injury is within the limits of the lower two-thirds of the bone.

Fractures of the Patella.

Fractures of the patella may be simple, compound, or comminuted. Occasional instances occur of fissure without entire separation of the bone. The direction of these fractures may be transverse, vertical, or oblique; and from the relation of this bone to the knee-joint, these injuries assume great importance. Of 2328 fractures at the Hôtel-Dieu, 45 were cases of broken patella.* Of the 8667 fractures received into the Pennsylvania Hospital from 1830 to 1874, a period of forty-four years, 148 were fractures of the patella. In 106 of this number, 86 were simple, 8 comminuted, 7 compound, and 5 compound comminuted.

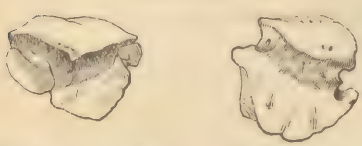
The relative frequency of the fracture in the sexes is quite remarkable. The records of the last-named hospital show that 96 were in males, and only 10 in females. Only one case was seen under twenty years of age, the largest number, 36, occurring between twenty and thirty. After fifty, the comparative infrequency of the injury is very marked. Occasionally both bones are broken simultaneously, and sometimes the same bone several times. Of the former, Dr. Kirkbride gives a case which occurred in the Pennsylvania Hospital;† Hamilton another;‡ Bichat and Sir Astley Cooper each report one;§ and one came under my own care in the Pennsylvania Hospital.

CAUSES.—These are direct violence and muscular action. In the cases which have come under my own observation, they have been produced most frequently by muscular action, and when the limb was in a state of greater or less flexion, in which position the bone, by its tendinous connection to the tubercle of the tibia below, and to the tendon of the quadriceps muscle above, is bent over the trochlear surface of the femur. In 29 fractures of the patella recorded by Hamilton,‖ 27 were produced by direct force, such as falls upon the knees, and 2 by muscular force. The most common instances of the action of muscular force in producing the fracture are those in which it has resulted from mounting a horse, the bone giving way when the rider is raising himself from the ground on the stirrup, from sudden efforts to escape a threatened

* Malgaigne on Fractures, Packard's trans., p. 599.
† American Journal of the Medical Sciences, August, 1835.
‡ Fractures and Dislocations, p. 435. § Malgaigne on Fractures, etc., Packard's trans., p. 602.
‖ Fractures, etc., p. 434.

fall in which the body is thrown violently backward, from the act of giving a kick, as in Bichat's and Malgaigne's cases,* and from the balancing efforts of rope-dancers, circus-riders, etc. The opinion of Malgaigne, that the accident, when from the causes just enumerated, is sometimes due to a diseased condition of the bone, is to be accepted only in a very restricted sense. I have seen many cases of fracture from extreme brittleness of the bones, but only once have I witnessed the patella broken in a person who labored under a fragility of the osseous system. Again, in individuals who suffer from such diseases as syphilis, cancer, and rheumatism, affections which so commonly deteriorate the osseous system, how rare is it to meet with this fracture! Lastly, in the aged, where we naturally look for the existence of a fatty change in the bones, a broken patella is quite uncommon, its frequency being inversely in proportion as we advance in life. From whatever cause, direct or muscular, the line of separation is generally transverse: occasionally it is oblique, and in a few instances vertical. (Fig. 810.) Only once in 106 cases was a vertical separation recognized.† A remarkable specimen is given by Bryant, taken from his father's museum, consisting of four transverse fractures.

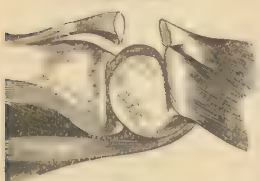
Fig. 810.



Comminuted fracture of the patella, the lines of separation being oblique. Transverse fracture of the patella united by fibrous tissue.

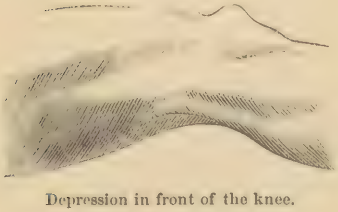
Symptoms.—When the patella is broken, severe pain will generally be experienced, with loss of power to extend the leg, and considerable swelling about the knee-joint. The upper fragment will be drawn up by the contraction of the quadriceps muscle (Fig. 811), the lower fragment remaining stationary, or only descending a little by its own weight. The contraction of the tendon which connects it with the tubercle of the tibia, alleged by Malgaigne to take place, is altogether insignificant. A depression will be seen between the fragments, into which the finger can be pressed. (Fig. 812.) This chasm, or sunken interspace, will be increased by flexing the leg, the lower fragment following the movements of the tibia. The degree of separation will depend on the amount of laceration sustained by the fibrous expansion of the quadriceps muscle in which the patella is lodged. In a very aged and distinguished artist of Philadelphia whom I attended for this injury, the fragments were quite four inches apart, and Sir Astley Cooper mentions a case in which the fragments were five inches asunder; but usually the interspace is from one-half to one inch. The power of extending the leg, though generally, is not always, lost. I have seen a case of this fracture in which a patient admitted to the hospital for a severe injury of the head was able to walk to his bed, the lesion of the patella not being discovered until several days after his admission. There was considerable separation of the pieces in this case. The limb is commonly found somewhat flexed. Crepitus is not easily produced, except in the comminuted or vertical variety, when the pieces are more easily brought into contact; the knee rapidly swells, and the joint becomes distended with fluid, which is sometimes intermixed with blood. This often masks the true nature of the injury, although the effect of this swelling is to widen the interval between the fragments. When the fracture is the result of direct violence, discoloration

Fig. 811.



Separation of the fragments of the patella by the action of the quadriceps muscle.

Fig. 812.



Depression in front of the knee.

* Malgaigne on Fractures, Packard's trans., p. 601.

† Willard's Tables of Fractures.

from extravasated blood will be diffused through the subcutaneous cellular tissue around the knee. The joint does not escape inflammation, and on the degree of this will depend its future usefulness.

Injuries to the bursa over the patella, when its sac is ruptured, somewhat simulate fracture; but the absence of the other signs which have been detailed ought to be sufficient to prevent any mistake being made.

PROGNOSIS.—The union which follows a fracture of the patella is usually ligamentous. Bony consolidation of the fragments is certainly of very rare occurrence. Professor Gross possesses a specimen in which the pieces appear to be conjoined by callus. Cooper mentions several cases of the same kind. Bryant figures another, taken from Guy's Museum, in which a section has been made; and Hamilton thinks he has seen it in two cases. I have never seen a specimen which entirely satisfied my mind of the verity of this union. Non-union is by no means uncommon. In 31 specimens which Mr. Adams examined, 15 were ununited,* 12 were united by fibrous tissue, and 4, from their dried condition, remained undetermined. The disability varies greatly in different cases, there being a singular want of uniformity in this particular even in cases apparently alike. In Kirkbride's case† the bond of union was two and a half inches in length, yet the patient experienced no inconvenience in the use of the limb. Others, again, with a much shorter union, find the limb weak and helpless: a certain degree of anchylosis often remains, the effect of inflammation of the joint tissue. Atrophy, with fatty degeneration of the quadriceps muscle, rendering the latter more feeble, may also follow this injury, and in some cases is permanent. It may be fairly stated that the limb in all cases, however close the intermediate union may be, is somewhat weakened and less able to endure fatigue than the sound one.

The character of the connecting bond has been shown by Mr. Adams‡ to consist, when the gap does not exceed one inch and a half, of organized fibrous tissue developed from the reparative lymph deposited between the fragments. When the separation is greater, the connecting bond consists of the fascia which lies over the bone, and which is somewhat thickened by plastic deposits. The arrangement of the uniting material has also been described by the same writer as passing between the anterior periosteal surfaces of the two pieces, reflected over, and adherent to both fractured surfaces, and finally, and most commonly, extending from the anterior periosteal surface of the upper to the broken surface of the lower fragment. The bursa over the patella is incorporated with the uniting structure, and no callus ever appears on the articular surface of the bone, the presence of which, as has been very properly remarked by Dr. Hunt, would be dangerous to the joint. Union may be expected to take place in from four to seven weeks.

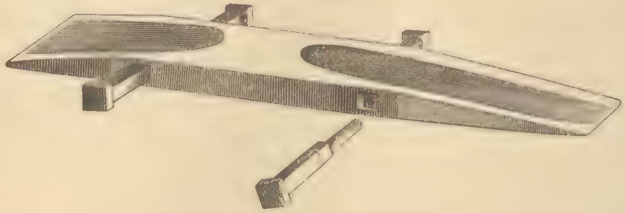
TREATMENT.—The indications are, first, to place the limb in that position which will secure the most complete relaxation of the quadriceps muscle; secondly, to bring together, and so retain, the parts of the fractured bone; and, thirdly, to prevent anchylosis.

Many of the older surgeons were content simply to place the limb in the extended position, with a view to fulfill the first indication; and this position is still advocated by some surgeons, among whom is Mr. Hutchinson,§ who thinks that the quadriceps muscle has nothing to do with the displacement, but that the deformity occurs in consequence of the effusion into the joint. This view, however, is not tenable. By raising somewhat the leg, the origin and insertion of the rectus muscle are brought nearer together, favoring the apposition. The apparatus which I employ is very simple, and one which any person with the slightest handicraft can quickly construct. It consists

* Cooper's Surgical Dictionary, vol. i. p. 753.
† American Journal of the Medical Sciences, vol. xvi. p. 32.
‡ London Pathological Society's Transactions, vol. xiii. p. 139.
§ Medico-Chirurgical Society's Transactions, vol. iii. p. 327.

of a piece of pine board, somewhat convex longitudinally on the upper surface, thirty inches long, and five inches wide at one end, tapering to four inches at the other. On each side, a short distance above and below the middle of the board, are to be bored two holes, into which are fitted four pegs with square heads. (Fig. 813.) This splint must be well padded, and

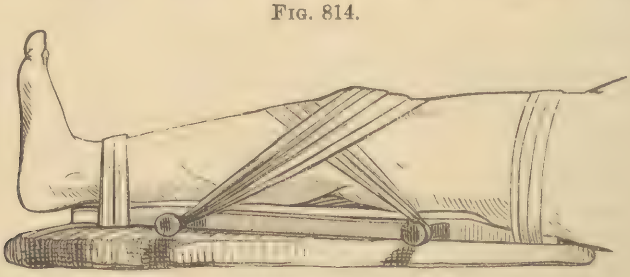
FIG. 813.



Author's splint for fractured patella.

placed under the thigh and the leg, the limb being at the same time moderately elevated. Below the knee and the lower fragment are next to be applied, partially overlapping each other, two or three strips of adhesive plaster, each three-quarters of an inch wide and thirteen inches long. These strips are brought together at their extremities, and wrapped round the upper pegs. This secures in position the lower fragment. Five strips of plaster, of like length and width, are next applied three or four inches above the knee, descending towards the joint, each strip overlapping one-third of the preceding one. Bringing the ends of the plaster together, they are to be wound around the lower pin, when, by screwing or twisting the pegs of the two sides, the lower fragment will be brought into near apposition with the upper. To prevent the broken surfaces from tilting forward, a broad strip of plaster may be drawn over the line of approximation and fastened to the splint below. A roller is now applied above and below, which secures the thigh and leg to the splint. (Fig. 814.) As the swelling subsides, all that

FIG. 814.



Author's splint applied.

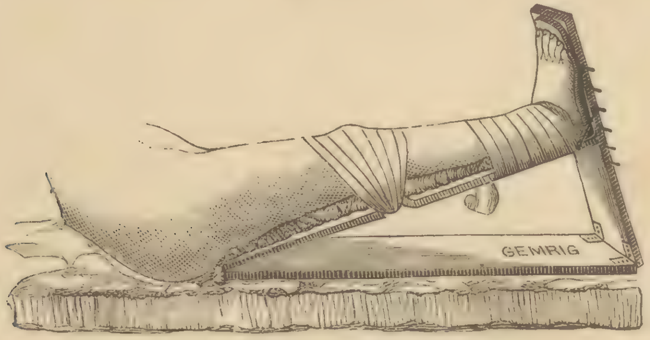
is necessary to maintain the adjustment is to tighten the strips by screwing up the pegs to which they are fastened. By this plan the removal of the dressing is rendered unnecessary until the cure is complete. Between the third and fourth weeks the strips may be separated from the pins, the knee gently moved so as to overcome stiffening, and the dressing again readjusted. This process should be repeated every five or six days, or until the fifth week, when the splint may be laid aside and the patient be placed on crutches.

Professor Hamilton employs an apparatus which may be used with great satisfaction. It consists of two boards wider than the limb and long enough to reach from the tuberosity of the ischium to the sole of the foot. These should be hinged together at their upper ends. Below, a foot-piece, having two fenestræ, is hinged to the lower board or base; the upper board has

two long tenons or tongues to pass through these fenestræ, so that the angle can be adjusted as required. A few gimlet-holes bored through one edge of the foot-board will serve for the insertion of a peg which shall keep the plane secure at its due elevation. I have had a movable convex block, two inches high, screwed to the upper board of this splint, so as to admit of its being placed exactly behind the knee-joint, by which a slight degree of flexion at the knee can be preserved, the straight position of the leg being as uncomfortable as is an extended condition of the elbow.

Application.—The plane for the limb being well padded, the injured extremity is placed upon it as soon as possible, and the board raised to an angle of thirty degrees, at which point it is fixed by the peg in the side. The foot must be placed at a right angle with the leg, and made fast to the foot-board, having a thin pad interposed. The body of the patient may be next raised to a semi-recumbent position, which gives the greatest relaxation to the rectus femoris muscle, and enables the surgeon to bring the superior fragment well down and retain it in place by a roller. This bandage is first carried above the upper fragment, then below the lower fragment, and lastly, by successive oblique and circular turns, each turn passing through the notch in the plane, the entire knee is covered in. With a second roller, beginning at the ankle, the entire limb is next bound to the splint. The patient should be visited daily, and the dressing carefully inspected to ascertain the condition of the limb. If there is no complaint, it need not be disturbed for two days, at which time the second roller may be removed, and if the uniting one about the knee is quite firm, the former may be again applied. Usually, on the fourth or fifth day the swelling in the articulation begins to subside, when the uniting roller should be reapplied with increased firmness. About the tenth day the swelling has so much abated that a more permanent dressing can be used, and for this purpose, removing the rollers, adhesive strips are applied in the same directions and order as were observed in the use of the uniting bandage, after which the limb is bound to the splint (Fig. 815)

Fig. 815.



Hamilton's splint for fractured patella applied.

with a roller, which, beginning at the ankle, ascends the leg to the knee, and is made to surround the latter by oblique and circular turns, passing through the notch in the splint, with a view to give additional fixation to the fracture, and finally terminating by ascending the thigh to the groin.

This dressing may be allowed to remain five or six days, when the roller should be removed and re-applied, the adhesive plaster remaining undisturbed. These strips may not require renewal during the progress of the treatment.

The first effect of almost any dressing is to evert the fractured surfaces, approximating their posterior edges at the expense of the anterior ones; but by the present method, in which the entire knee is covered in, this ever-

sion is corrected. In the absence of this splint, a single board, wider than the limb and notched opposite the knee, can be used, raising the lower extremity to the proper height, and supporting it on some firm base. At the end of the fourth or fifth week it will be proper to attend to re-establishing the functions of the articulation. The dressings must be removed and gentle flexion and extension of the joint made every two days, taking care not to presume too much on the strength of the union. At this stage of the treatment the adhesive plaster is dispensed with and the roller only used to fasten the limb to the splint. About the fifth or sixth week the patient may be allowed to move about on crutches; but no attempt at walking should be attempted unassisted sooner than from the ninth to the twelfth week.

It is proper also to wear for several months a laced knee-cap, with an opening in front corresponding to the patella, so as to take off as much as possible all tension from the uniting tissue, which is prone to become elongated and thus allow the fragments to separate. This precaution acquires additional force when it is remembered that a slip or a stumble may snap asunder the fibrous union.

When a fragment is broken off from the patella, or in a simple comminuted fracture of the bone, or when the latter is severed vertically, a compress should be placed on each side of the bone previous to the application of the adhesive strips or the roller. It may happen that the joint will have received severe injury, and that the inflammatory symptoms which ensue are of the greatest severity,—such as to create anxiety for its safety. Under these circumstances, the limb must be extended and elevated upon a pillow, blood drawn by leeches, and the articulation surrounded with bags of ice, or kept under water irrigation, until the danger is over, when the apparatus may be applied.

Compound Fractures of the Patella.—These are injuries of the greatest severity, usually opening the joint, and resulting in erysipelas, pyæmia, exhaustive suppuration, and death. I have seen a patient die in a few days from the ravages of erysipelas, after such an accident produced by the kick of a horse. Mr. Poland, in a very valuable paper on this subject, has shown that in compound fractures of the patella, where the question of amputation arises, statistics are, as a rule, against the operation. For instance, of 68 cases treated without amputation, 56 recovered,—82.35 per cent.,—while in 7 in which the operation was performed, 5 recovered,—71.42 per cent. In 10 cases in which excision was performed, 6 died,—60 per cent. In all the fatal cases, suppuration of the articulation was present, and it also existed in 43 out of the 65 cases which recovered; 31 of the recoveries suffered more or less from anchylosis of the knee-joint.

Treatment.—If the fracture is compound, an attempt should be made to convert it into a simple one, by immediately closing the external opening. If the injury is a comminuted one, any loose fragments of bone which are present must be removed and the limb either suspended by the anterior splint of Nathan R. Smith, or placed upon a single slightly-inclined plane. Energetic measures will be demanded in order to prevent a destructive arthritis. Persistent irrigation with cold water containing laudanum should be employed, or the articulation may be surrounded with bladders filled with broken ice. If the swelling, heat, and pain prove to be great, leeches should be applied, and, in order to drain away the redundant transudation from the joint, horse-hair may be introduced through the wound. Pain is to be alleviated or controlled by the free use of opiates, and, as there will generally be considerable constitutional disturbance present, these anodynes are best exhibited in some febrifuge like the neutral mixture.

Should the inflammation result in suppuration, the cold applications must be discontinued, and the strength be sustained by the use of quinine, iron, stimulants, and a generous diet. To supply a ready exit for the pus, a free

incision into the joint will be required, after which the knee may be enveloped either in a flaxseed-meal poultice or in a warm-water dressing.

When the injury is followed by a profuse discharge of purulent matter, by free lateral movement of the articulating bones, by crepitus the result of eroded cartilages, and without any tendency to anchylosis, the indications are that the joint has been ruined, and the only hope for the patient lies either in amputation or in excision. In an adult, the former operation would offer the best chance for recovery, while the latter should have the preference if the subject be young.

The ligamentum patellæ may be broken. This is a very rare occurrence, but it has been noticed twice at the Pennsylvania Hospital. I think it probable that the tip of the patella was detached in these cases, rather than that the ligament was lacerated.

I once witnessed an instance of rupture of the quadriceps muscle immediately above the patella, in the person of a Catholic priest who slipped and fell upon an icy pavement.

The treatment appropriate to these injuries does not differ from that proper to a case of fracture of the patella.

Other methods.—Many other methods have been and are still in use in the treatment of fracture of this bone. Paulus Ægineta, and other ancient surgeons, trusted largely to extension alone by means of splints.

Flajani applied no dressing whatever, relying on rest and fomentations for a number of days, and then practicing frequent movements of the joint. This method, slightly modified, was a popular practice over a century ago in London.

Others relied on rings made of different materials, such as wood, cork, wire, etc. These were covered or padded before their application, so as to protect the soft parts from undue pressure. Albucasis, we learn from Malgaigne,* was the first surgeon to suggest this mode of dressing. The fragments were drawn together and brought within the compass of the ring, which was bound to the knee with a roller, the limb at the same time being kept in the extended position.

Another principle introduced into the treatment of this fracture was the application of forces acting obliquely and in opposite directions. The originator of this plan, we are informed by Malgaigne, was a non-professional man,—a mechanic in Leyden. In some form or other it embraces almost all the mechanical appliances which have been in successful use in the management of this fracture for over a century. Thus, we have the figure-of-eight bandages of Petit, Velpeau, and others, as below enumerated.

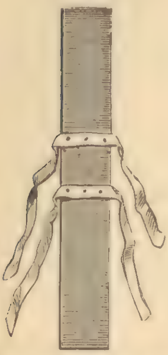
Boyer's apparatus consisted of a concave splint, well padded, extending along the posterior part of the limb, with nail-heads on each side opposite to the knee-joint, and two straps covered with soft chamois leather. One of these straps passed above and the other below the patella; the upper one, running obliquely downward, was buttoned on the nail-heads below, while the lower one was carried obliquely upward, and attached to the nails above.

Desault's method.—After the same principle was the dressing of Desault, in which the limb was extended and elevated, and along its anterior surface, running from the groin to the ankle, was laid a strip of bandage, which was bound to the leg by a spiral reversed roller, beginning at the foot. Upon reaching the knee, two longitudinal slits, one on each side of the patella, were made in the muslin strip, through which the fingers of the surgeon were passed, in order to draw the upper fragment down into place, after which the roller was resumed, forming figure-of-eight turns about the knee, so as to hold the broken pieces together, the bandage then being ex-

* Malgaigne on Fractures, Packard's trans., p. 614.

hausted by ascending the thigh to the groin. This completed, a straight, cushioned posterior splint was bound to the back of the limb, from the nates to the heel, and its lower end elevated at a considerable angle with the bed.

Fig. 816.



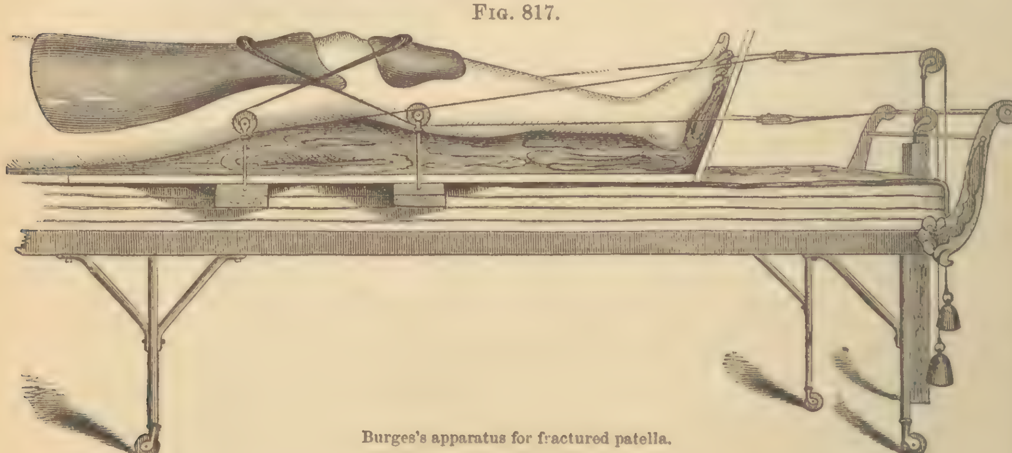
Dorsey's splint for fractured patella.

Dorsey's splint forms another illustration of a fracture device. It was a wooden splint long enough to extend from the tuber ischii to the heel, with two strips of muslin nailed crosswise, four inches apart and equidistant from the centre. (Fig. 816.) The foot and limb were covered in with a roller, and the splint, well padded, was placed in position. The upper strip was tied over a compress placed below the lower fragment, and the lower one over a pad fastened above the replaced upper fragment.

Lonsdale's apparatus acts in the same manner. It is a posterior splint with a movable foot-board, and two vertical iron bars rising on either side of the knee, each having a horizontal bar to which is attached a semilunar piece of metal, which, by a screw movement, can be made to press together the fragments. The complicated nature of the mechanism, even if it had no other defects, would constitute a valid objection to its use.

Burges's apparatus (Fig. 817), though very beautiful and neat, is alto-

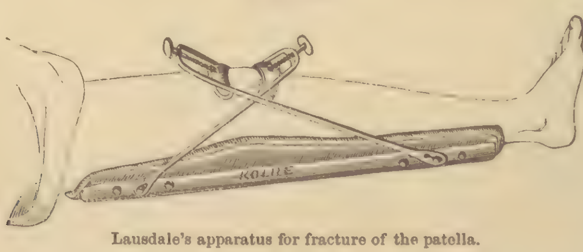
Fig. 817.



Burges's apparatus for fractured patella.

gether too complicated for general use. Two concave sole-leather splints, one long and the other short, are used: the long splint is placed upon the

Fig. 818.



Lausdale's apparatus for fracture of the patella.

thigh above the patella, and the other on the leg below the lower fragment, after which they are drawn towards each other by cords, pulleys, and weights.

The apparatus of Lausdale (Fig. 818) and that of Boisnot (Figs. 819, 820) are much more simple, and are the best forms of these splints.

By the first, the fragments are forced towards each other by means of thumb-screws acting in front of the limb; by the last, the approximation is effected by the action of screws and ratchets beneath the posterior splint.

Fig. 819.

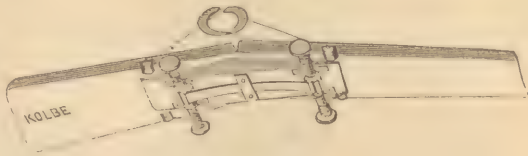
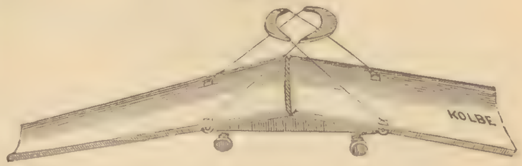


Fig. 820.

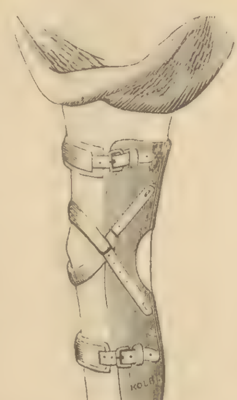


Boisnot's apparatus for fracture of the patella.

Hartshorne's apparatus consists of a slightly angular tin splint fashioned to the form of the posterior part of the limb, and having in it an oval opening corresponding to the ham, with straps and buckles above and below to secure it to the thigh. It has two straps designed to pass obliquely above and below the fracture, to be fastened to hooks on the sides of the splint. (Fig. 821.)

Gerdy's dressing is one which can be readily prepared, but has no special advantages over other forms of apparatus. Two strips of muslin are provided, one with three slits and the other with three tails. The first strip is placed so that the slits will answer to the edge of the lower fragment; the second strip is laid upon the front of the thigh, and each is bound in position by separate rollers, one below and the other above the knee. The approximation of the fragments is next effected by passing the tails of one strip through the slits of the other, and securing all together by a spiral reversed bandage extending from the foot to the groin. (Fig. 822.)

Fig. 821.



Hartshorne's apparatus.

Fig. 822.

Gerdy's dressing.

The apparatus used by Wood, of King's College Hospital, London, and that of Dunnage, operate on the same general principle.

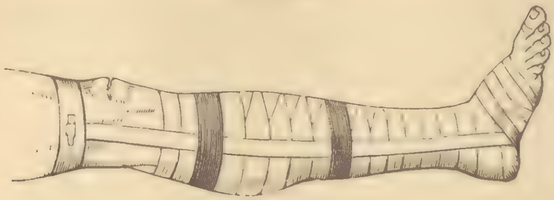
The approximation has been attempted also by means of forces acting longitudinally.

Sir Astley Cooper's dressing was of this kind,—one in which the limb was encircled by two strips of roller, one above and one below the patella, and then the fragments were approximated by passing two tapes, one on each side of the knee, from one circular band to the other, drawing these together, and afterwards covering the limb—in the extended position—with a roller. This plan is attended with much local uneasiness, from the constriction to which the limb is subjected, and although it is termed the dressing of Sir Astley Cooper, it is one which that surgeon abandoned, believing that

he had found a better method. This consisted in waiting for a few days until the painful tumefaction was over, and then encircling the thigh above the patella with a soft leather strip. A second strip was placed under the foot, and its two ends were carried up on either side of the leg and buckled into the first. (Fig. 823.)

Levis's mechanism.—The contrivance of Dr. Levis acts much in the same way. (Fig. 824.)

Fig. 823.



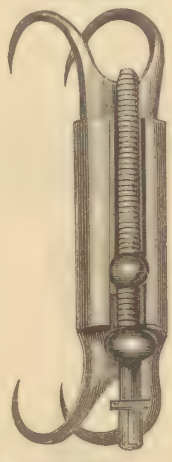
Sir Astley Cooper's dressing for fractured patella.

Many others, such as the dextrine dressing of Velpeau, the uniting bandage of Petit, etc., might be described, but I shall speak of but a single one more,—that of Malgaigne,—by which the fragments are brought together by means of hooks. (Fig. 825.) These curved hooks are separated and applied singly, the one being pressed down upon the apex of the lower fragment, and the other upon the superior border of the upper fragment, the skin being previously drawn forward from between the fragments, and then the hooks are approximated by a screw. Once have I seen death follow the use of this infernal machine, from an erysipelatous inflammation extending into the joint and giving rise to abscesses, both within and without the articulation. No advantage whatever results from the close contact of the fragments accomplished by the instrument: it is rather a disadvantage, as the tendency to refracture is increased by the very closeness of the union, the intermediate bond not being as strong as the ordinary fibrous tissue which fills the gap when the pieces of the bone are a short distance apart. Three times have I seen the union broken a few weeks after the patients treated by this method had been discharged from the hospital.

Fig. 824.

Levis's apparatus.

Fig. 825.



Malgaigne's hooks.

Fractures of the Bones of the Leg.

Fractures of the bones of the leg are largely in excess of those of other parts of the skeleton. Of the tabulated 8667 fractures treated in the Pennsylvania Hospital. 2315 were fractures of the bones of the leg. Of 1101 cases received into the Middlesex Hospital, 289 were fractures of these bones.* In 222 cases taken from the records of Guy's Hospital by Dr. King, 66 were situated in the leg. Malgaigne found, from the records of the Hôtel-Dieu, that there were 652 in a total of 2328.

* Lonsdale on Fractures, p. 17.

Fractures of both bones are more frequent than those of either bone singly. By a reference to the table it will be seen that, of 2315 fractures of the leg, 437 were in the tibia, 437 in the fibula, and 1441 in both bones. The lower third of the leg is the most common seat of fracture, and the middle third the next. This is true of the bones either separately or conjoined, and is doubtless due to their exposed condition from the small amount of soft parts in these localities, as well as to the fact that these are the weakest portions of the bones. It will also be seen by a reference to the table that of 246 fractures of the tibia, 120 were in the lower third, 81 in the middle third, and 45 in the upper third; that in 252 fractures of the fibula, 210 were in the lower and 26 in the middle third; and that in 751 fractures of both bones, 399 were in the lower and 282 in the middle third. The largest number of fractures of the bones of the leg occur between twenty and thirty years of age.

Sex exercises its influence also, males furnishing by far the greater number of such accidents. This disparity, however, diminishes as we advance in life, until after seventy-five, when females are in the majority. These injuries may be considered under three heads: 1, *fractures of both bones*; 2, *fractures of the tibia*; 3, *fractures of the fibula.*

Fractures of the Tibia and Fibula.

Causes.—The causes are either direct, such as the passage of a wagon-wheel, the kick of a horse, or the falling in of earth, or of massive portions of stone; or indirect, as when a person falls from a height, or jumps from a carriage or a car which is in swift motion. When determined by indirect or transmitted force, Malgaigne thinks the fracture is likely to take place near the middle of the lower third. This locality, being at the summit of one of the curves of the bone, is necessarily more within the influence of this kind of force than would be parts more remote. As far, however, as my own observation extends, I have not found any such uniformity as is claimed to exist between the seat of fracture and this kind of force, one example of which is seen in Fig. 826. When produced by direct force, the lesion will generally occur at the seat of violence. For example, a young man sitting upon the balustrade at the Philadelphia Academy of Music lost his balance, and would have been precipitated headlong some thirty feet, had not one foot caught between the rounds of the railing. His entire weight was supported by the ankle, and both bones broke at the lower part of the lower third. A heavy piece of iron fell upon the leg of a moulder, while engaged at his employment; the tibia and fibula were both broken at the point struck by the metal. I could relate many instances where persons have fallen when the foot was wedged in between unyielding surfaces, the fracture always taking place at the lower portion of the lower third of the leg.

Fig. 826.

Fracture at the upper extremity of the tibia and fibula, caused by indirect force.

Occasionally these fractures result from muscular action alone; such instances are always found in adults. I have seen two cases of intra-uterine fracture of both bones of the leg. A colored man was brought into the Pennsylvania Hospital with a fracture of the tibia and fibula, four inches above the ankle, which was caused by the violent muscular effort made to recover his equilibrium after slipping upon an orange-peel. He was thirty years of age, of an excellent constitution, and without any evidence whatever of pre-existing bone disease. He had never before had a fracture.

The two bones are seldom broken exactly at the same level. Usually the fracture of the fibula is higher than that of the tibia; and sometimes when the latter bone is broken a short distance above the ankle, the former will be found separated near its upper extremity. When broken nearly on the same level the force has generally been direct, but when the lesions in the two bones are widely separated it has usually been indirect, each bone yielding at its weakest point; or the rationale may be the one given by Malgaigne, in which both direct and indirect force is in operation. For example, a man is struck forcibly by some vulnerating body across the lower part of the leg while in the erect position. The tibia gives way at the seat of injury, and, in struggling to maintain his footing, the weight of the body is borne by the fibula alone, which in turn gives way at the upper third, its most slender part.

Compound and compound comminuted fractures of the bones of the leg exceed in frequency those of any other bones of the skeleton. Of 1074 cases of such fractures received into the Pennsylvania Hospital, 366 belonged to these classes. The superficial position of the tibia and fibula will explain these figures. The direction of the fracture is always more or less oblique, running downward and inward, and less frequently downward and outward. The obliquity is least when near to the upper or lower extremity, and where, especially in the tibia, the bone is most voluminous, so that these breaks are sometimes spoken of as transverse fractures. It is in the same localities that the line of separation is prone to be vertical, splitting the bone and extending into the ankle- or knee-joint.

Symptoms.—The signs of fracture of both bones of the leg are usually well pronounced. These are contusion, discoloration, pain, deformity, undue mobility, and crepitus. Malgaigne attaches much importance to the muscular state of the limb as a sign of this fracture,—a condition which is certainly very common. The deformity will depend on the degree of displacement. In many instances there is little or none, particularly when the bones are broken at different levels, in consequence of which there is often an interlocking of the spiculæ which tends to oppose the disarrangement of the pieces. When the fracture traverses a voluminous part of the bone, as that near to the tubercle, some portion of the broken surfaces will remain in contact, and thereby lessen the deformity. In other cases the displacement is very considerable, and is often determined by the violence which causes the injury. That which is sometimes witnessed consists in the anterior projection of the upper end of the lower fragment; but by far the most common displacement is the lateral one, the lower slipping to the fibular side of the upper fragment. The gastrocnemius and soleus muscles are chiefly concerned in producing this deformity, as by drawing the foot back they not only carry the lower pieces forward, but likewise produce overlapping of the fragments and consequent shortening. (Fig. 827.) When the fracture is caused by a force applied to the front of the leg, the line of separation may be from below upward and from before backward, in which case the lower fragment will assume a position behind the upper one. The action of the quadriceps muscle in tilting forward the upper part of the tibia is altogether insignificant, as this movement is counteracted by the posterior and crucial ligaments of the knee-joint.

Fig. 827.

Anterior angular deformity and overlapping following fracture of the bones of the leg. The displacing muscles, viz., the gastrocnemius and the soleus, seen on the posterior aspect of the cut.

Lateral angular deformity, when present, is generally due to the direction of the fracture—of which I shall speak hereafter—and to the weight of the parts, accompanied by an unequal support of the leg, or, when the angle is salient internally, to the action of the peroneal muscles drawing the foot outward.

Another displacement, and not an uncommon one, is that in the longitudinal axis of the bones, caused by either external or internal rotation of the foot, in most instances the former. In 19 cases of ununited fracture of the bones of the leg, Mr. Shaw found the lower fragment rotated outward 16 times.

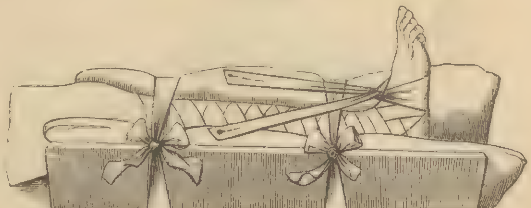
PROGNOSIS.—The prognosis will be influenced by several considerations,—such as the damage done to the soft parts, the degree of comminution, the obliquity of the fracture, and the amount and kind of displacement. When the soft parts are lacerated extensively and the bones broken into several pieces, or when in connection with this laceration the tibial arteries are torn, amputation is the only resort. If, as a consequence of great obliquity, there is much overlapping, and this is not corrected, the union will be slow, or may fail altogether. Rigidity or anchylosis of the knee or of the ankle is occasionally a sequel to delayed union, and, according to my experience, is more common in the bones of the leg than in any other part of the skeleton. Where, however, none of these complications exist, fractures of the leg heal rapidly, so that the cure is usually effected in four or five weeks, and without any marked deformity or shortening.

TREATMENT.—Very frequently little is to be done in the way of adjusting the fracture,—so trifling is the displacement,—only requiring that the leg be placed in some suitable retentive apparatus. At other times the displacement is very marked, and requires no small amount of patience and judgment to correct it. When it is lateral, the foot must be brought into a line with the upper part of the leg, which may be all that is required. Should there be overlapping, extension from the foot and ankle and counter-extension at the thigh must be made until the reposition is complete. To obtain the full benefit from these two forces, it will sometimes be necessary to flex the leg in order to render powerless the resistance of the gastrocnemius and soleus muscles. The semi-flexed position alone will frequently correct the malposition of the fragments when force has proved entirely unavailing. Various little changes of position will occasionally be necessary, which must be learned by repeated trials, as they cannot be predicated on any knowledge of muscular action, while they differ so much in detail that no one case serves exactly as a precedent for another.

Two positions have been advocated for the treatment of fractures of the bones of the leg,—the *extended* and the *flexed*. With few exceptions, the extended position is the one to be preferred. The dressing necessary for the retention of these fractures is very simple, and always accessible.

Board and pillow or Boyer dressing.—Place across the bed three strips of roller one yard long; upon these lay a piece of muslin two feet long and one yard wide, and upon this an ordinary feather pillow. Thus arranged, the broken limb is laid upon the dressing. Two pieces of light board five inches wide, and long enough to extend from the knee to three inches below the foot, are next rolled in the splint-cloth or muslin, so that they shall be made to apply themselves firmly along the inner and outer aspects of the leg, the pillow being interposed, after which they are made secure by tying together the ends of the three strips of muslin. To support the foot and prevent the toes from falling forward too much, pass a loop of muslin over the metatarso-phalangeal part of the foot, and pin its extremities to the pillow on either side. (Fig. 828.) The bandage of Scultetus, used by Boyer, may be omitted. The weight of the bedclothes must be kept from the foot by a rack. Nothing can be more simple, and the materials are within the reach of every one. This dressing is suited

FIG. 828.

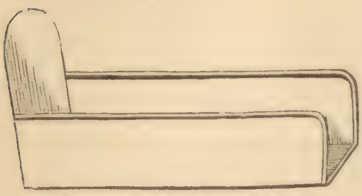


Boyer's dressing for fracture of the bones of the leg.

to a case in which there is little displacement, and no overlapping, and where extension is not demanded.

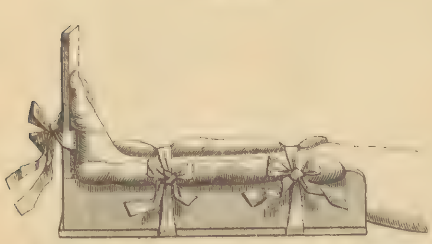
Fracture-box.—Next in simplicity is the old fracture-box (Fig. 829), which combines so many advantages that I regard it, notwithstanding all that has been said against its use, as an exceedingly valuable apparatus, answering in a large majority of cases every indication demanded. It is a box with a foot-board, through which are cut two vertical slits, and with sides attached by hinges, which may be raised or let down at pleasure. It should be long enough to extend from the knee to the sole of the foot. To apply the apparatus, place under it two or three strips of muslin, let the sides be opened, a pillow laid in the box, and upon this place the broken limb, with the sole of the foot touching the foot-board, cotton being interposed; next take a strip of muslin or a silk handkerchief, pass it beneath the leg just above the heel, cross it over the ankle and instep, then under the sole of the foot, where a single knot should be made, and the ends passed through the slits in the foot-board. The next and most important part of the dressing is the careful adjustment of the fracture and the proper distribution of the support beneath the leg and foot. Let the fingers be passed along the spine of the tibia, in order to ascertain if there is any irregularity, and thus determine the accuracy of the coaptation. If the upper end of the lower fragment is found above the level of its fellow, cotton or oakum must be placed under the tendo Achillis and the heel, in order to raise the foot; or if the fragment projects backward,—certainly a very uncommon position,—the heel should be lowered. Should the upper fragment rise above the level of the lower, it must be pressed down and a thick compress laid over the displacement. The toes should be turned very slightly outward, so that the ball of the great digit will be on a line with the inner edge of the patella, and, in order accurately to coaptate the broken ends of the bones, the heel must be raised or lowered by pledgets of oakum, according to the requirements of the case. These points being attended to, the loose ends of the strip which encircled the ankle and were passed through slits in the foot-board should be tied together, the sides of the box brought up to the leg, forcing before them the pillows, which furnish the lateral pressure; then keep them in place by tying together the ends of the strips which underlie the box. (Fig. 830.) When it becomes necessary to make anterior pressure, one of these strips should be tied directly over the thick compress previously mentioned, or, with a view to distribute the pressure over a larger surface, a thin book may be interposed between the compress and the strip. All anterior pressure must be carefully watched, as the soft parts are too thin to tolerate any considerable amount, particularly if they are stretched by the bone, or in the least inflamed, in which event pressure will be improper. With the dressing just described, the limb is always exposed to view, its condition readily ascertained, and any displacement immediately detected.

Fig. 829.



Fracture-box with hinged sides.

Fig. 830.

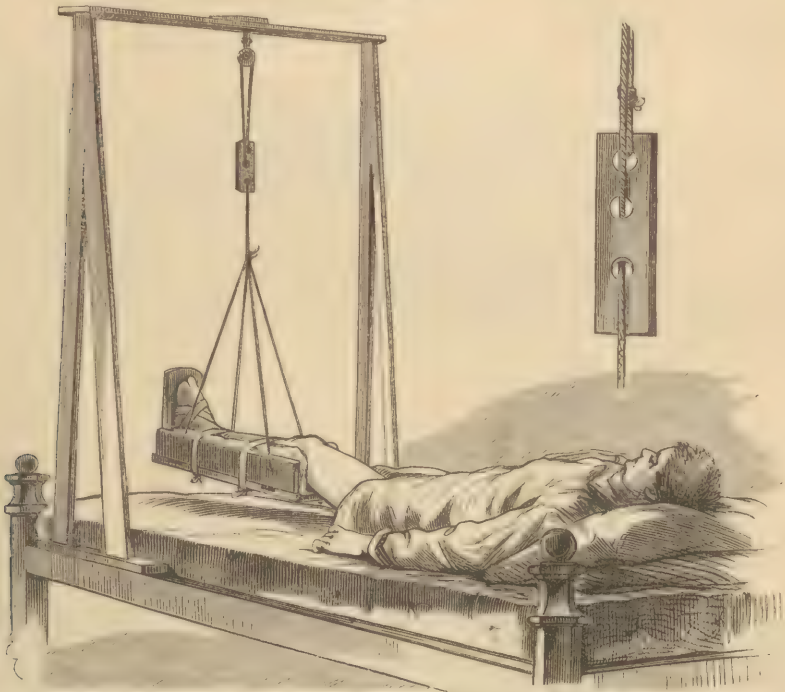


Fracture of the leg dressed with the fracture-box.

Among the objections urged against the fracture-box is that it allows the foot of the patient, when he attempts to rise or to sit up in the bed, to press against the foot-board, and thereby to cause overlapping of the fragments.

In the Pennsylvania Hospital, where the apparatus has long been in use, no such effects are observed to occur. If, however, there should be a risk of this displacement, or if the patient happens to be intractable or restless, the remedy to meet all emergencies is a very simple one, and consists in suspending the box to a crane or gallows placed over the bed: indeed, even where no such contingencies as those spoken of exist, I find that this arrangement proves a source of incalculable comfort as well as of safety to persons suffering from these fractures. In fitting up this apparatus, all that is necessary is to bore two holes near the upper borders of the sides of the fracture-box, about fourteen inches apart, and to tie into these two cords, which, being brought together, are fastened to a suspension-rope which runs over a pulley secured to the gallows-frame. In order to raise and lower the box at pleasure, the suspension-rope is connected to and passed through the holes in a block of hard wood, as represented in the figure below. The position of the box can be shifted to one side of the bed or to the other, by sliding in the required direction the block into which the pulley is screwed, the cross-piece of the frame having a fenestra cut for that purpose. (Fig. 831.)

FIG. 831.



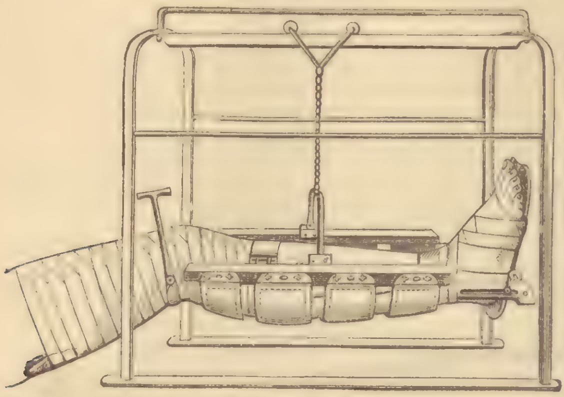
Fracture of the leg treated by the box and suspension apparatus. Also block with three holes, one end of the suspension-rope being tied into the upper hole, and the other passed through the two lower holes.

Every movement of the patient is imparted to the suspended box, so that, whether he rises or inclines to one side or the other, the limb itself cannot be disturbed. This dressing is in every way superior to that of Salter, which consists of a tin case adjusted to the posterior surface of the leg and placed in a sling, which is suspended to two wheels, constructed to run on the centre-bar of a cradle placed over the limb. (Fig. 832.)

Treatment of overlapping.—Cases will be encountered in which there is overlapping, and where it becomes necessary to modify the treatment so that this may be overcome. To accomplish this there are two methods, which are the opposite of each other, namely, extension and flexion. Remove the hair from the leg and apply adhesive strips two inches wide

along its sides, extending upward as high as the upper end of the lower fragments. The longitudinal strips of plaster should be rendered additionally secure by circular ones. The leg being now placed upon a pillow in the fracture-box, the ends of the plaster must be conducted through

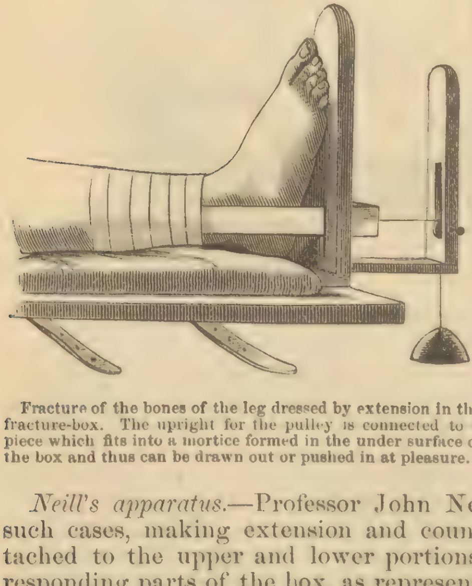
FIG. 832.



Salter's cradle.

vertical slits in the foot-board, and fastened to a piece of board, forming a stirrup similar to that used in the extension apparatus for the thigh. To this stirrup a cord is to be attached, running over a pulley, and a weight fastened to its extremity. (Fig. 833.) If the fracture is near the ankle, the adhesive strip may be applied in the form of a spica about the heel and instep. (Fig. 834.) If the weight required to make the necessary extension is great, it will be necessary to elevate the foot of the bed, as in fractures of the femur. The lateral support of the leg is supplied by bringing up and securing the sides of the box with strips of bandage.

FIG. 833.



Fracture of the bones of the leg dressed by extension in the fracture-box. The upright for the pulley is connected to a piece which fits into a mortice formed in the under surface of the box and thus can be drawn out or pushed in at pleasure.

FIG. 834.

Adhesive plasters applied to the heel and instep.

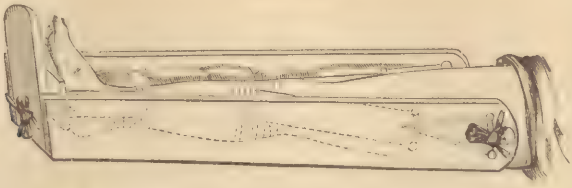
Neill's apparatus.—Professor John Neill employs a long fracture-box for such cases, making extension and counter-extension by adhesive strips attached to the upper and lower portions of the leg, and connected to corresponding parts of the box, as represented in Fig. 835.

By sawing the sides of the box down at the knee, this apparatus can be used with advantage in cases of compound fracture of the leg where it is

necessary to maintain extension and counter-extension, as the lower sides can be let down without in any way affecting those forces. (Fig. 836.)

When the fracture is so low down that sufficient extent of surface for the extending plasters cannot be had to insure their adhesion when the weight

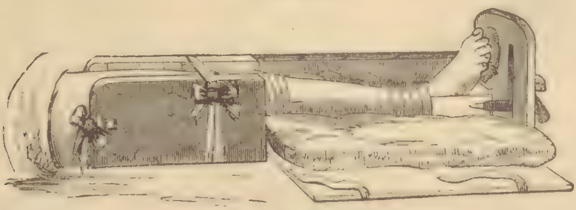
FIG. 835.



Professor Neill's mode of applying extension and counter-extension in fractures of the leg with overlapping.

is attached, or when the surface is so damaged as not to admit of their application, we may, in some cases, resort with great advantage to the plan of

FIG. 836.



Professor Neill's long fracture-box for the treatment of compound fractures of the leg with overlapping.

flexion, or the method of Pott. A light piece of board, long enough to extend from above the knee to two inches below the foot, is cut so as to conform to the leg and a portion of the thigh in the semi-flexed position of the limb. (Fig. 837.)

FIG. 837.

Splint for treating fracture of the bones of the leg in the Pott position.

This splint is to have an opening for the external malleolus, and should be covered with abundance of padding. The leg being flexed, and the requisite extension and counter-extension made to correct the deformity, its outer surface should be laid upon the splint, all inequalities filled up with cotton or oakum, and the outside of the foot raised so as to keep it in line with the great toe and the inner margin of the patella. Along the internal aspect of the limb, from the ankle to the knee, a second splint of binders' board should be applied, previously well softened in hot water so as to admit of its being moulded to the part, and having an opening for the internal malleolus, with padding interposed. These two splints can be secured to the leg by strips of adhesive plaster, or, what is better, by a roller bandage. The patient can lie upon the back or incline to the injured side, as may best comport with his comfort.

When the shortening persists and cannot be corrected by the best-appointed efforts, the tendo Achillis may be divided subcutaneously, and the subsequent treatment carried out either in the position just described or in the extended one, in the fracture-box.

In uncomplicated cases, after the lapse of two or three weeks, or after the swelling has subsided, an immovable appareil may be applied, and the patient be allowed to sit up, or to move about on crutches. For this purpose two

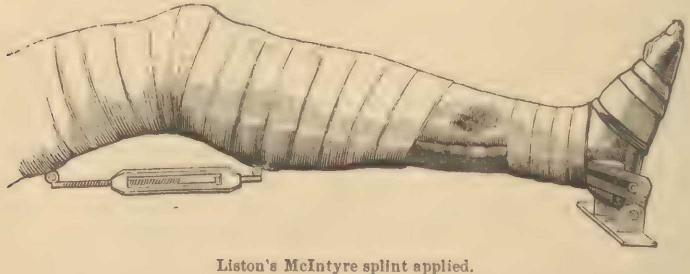
pieces of light binders' board should be cut, one for each side of the leg, long enough to extend from the knee to the toes, and fashioned so as to correspond to the figure of the limb and the foot. (Fig. 838.) These should be thoroughly softened in hot water, and after applying a roller to the leg (observing particularly to pad well with cotton about the malleoli, tendo Achillis, and spine of the tibia) should be moulded neatly to the inner and outer aspects of the leg and foot, and made fast by two or three spiral reversed rollers, each one receiving a coating of liquid glass or of starch. In twenty-four hours the dressing will be sufficiently firm, and the patient may be relieved from the tedium of the bed. This may be worn for two or three weeks, when all dressings may be discarded and attention given to the motions of the ankle- and knee-joints. A less cumbersome and equally efficient dressing can be made with plaster rollers, in the use of which it is only necessary to apply first a dry roller to protect the skin, and over this the plaster bandages, which, as soon as the gypsum sets, will form a perfectly secure case for the limb. A patient ought not to venture his entire weight upon the limb before seven or eight weeks have elapsed.

FIG. 838.

Binders' board splint for fracture of the leg.

Various other forms of apparatus are in use for the treatment of fractures of the legs. Among these may be mentioned Liston's modification of McIntyre's splint, which, having a joint at the knee and a screw between the leg- and thigh-pieces, may be used either as a straight splint or as a double inclined plane. The pieces for the support of the leg and thigh are so made as to admit of being shortened or lengthened and thus answer for the limbs of different patients. The splint being well padded, the foot is first secured to the foot-piece by the turns of a roller, and afterwards the leg and the thigh, leaving, in case of a compound fracture, the wound uncovered. Counter-extension is made by the thigh resting against the thigh-piece, the apparatus being in the form of the double inclined plane. (Fig. 839.) Splints

FIG. 839.

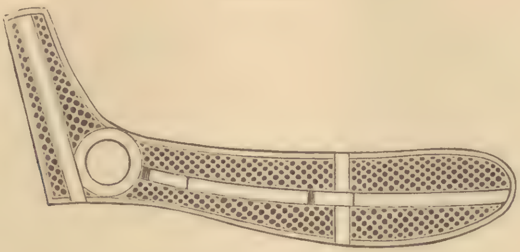


Liston's McIntyre splint applied.

made of wire, as those of Bauer, or of tin (Fig. 840) have been recommended. In oblique fractures, and when the upper fragment tends to rise above the level of its fellow, Malgaigne has devised and used a steel segment, with an opening at each extremity, through which is passed a leather strap, having a buckle at one end. At the summit of the steel arch is fitted a screw with a sharp point. The limb is laid upon a double inclined plane well padded, the steel arch is placed across the leg a little above the seat of fracture, and

the point of the screw pushed boldly down to the bone. The strap is buckled beneath the splint, and, if necessary, the screw may be turned until the frag-

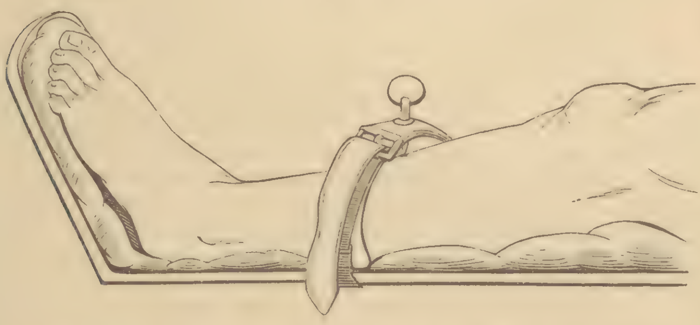
FIG. 840.



Perforated tin splint.

ments are brought into close contact. (Fig. 841.) This apparatus, like the hooks of the same distinguished surgeon for fracture of the patella, is capable

FIG. 841.



Malgaigne's apparatus for oblique fracture of the leg applied.—From Malgaigne.

of doing much evil by exciting erysipelas, and the case which would justify its use must be very exceptional indeed.

Another plan of overcoming the shortening is to take two pieces of binders' board, moulded to the sides of the leg and foot, similar to the appliance shown in Fig. 838. When dry, cut two pieces of adhesive plaster which is spread on both surfaces, corresponding to the form and size of the splints. On the inner side of these the plasters are to be laid down smoothly and made to adhere. Let the hair next be cleanly shaven from the limb, and the skin well cleansed and dried; while extension and counter-extension are being made so as to restore the leg to its proper length, warm the plaster surface of the two splints, then place one on each side of the leg, and make them fast by the turns of a roller extending from the foot to the knee.

Fractures of the Tibia.

Fracture of the tibia alone is much less common than fracture of both bones of the leg, and about as frequent as fracture of the fibula, these bones being each broken 437 times in 8667 cases of fracture received into the Pennsylvania Hospital. That it should occur independently of any similar injury to the fibula, a bone so very slender and delicate, is due to its exposed position,—a considerable portion being subcutaneous,—and also to its tarsal articulation, in consequence of which the force of falls upon the foot is transmitted directly to the bone. The superficial position of the tibia renders it peculiarly liable to compound as well as to comminuted fractures. It may be

broken in any part of the shaft or through the extremities. In 246 cases recorded in the table, 45 were in the upper, 81 in the middle, and 120 in the lower third. The most common displacement is a lateral one, the fragments overlapping, the lower being on the fibular side. (Fig. 842.) The fracture occurs with about equal frequency on the two sides. A case of separation of the upper epiphysis in an infant, through the violence of a midwife, reported by Madame Lachapelle, I have already referred to when treating of fractures of the condyles of the femur. This case, so far as I know, is unique. Several cases of separation of the lower epiphysis have been recorded: one by Quain,* in a boy seventeen years old, who fell with his foot doubled under him; another by Holmes;† a third by Voss,‡ in a boy of fourteen; and a fourth by R. W. Smith,§ in a boy of sixteen. A lad ten years of age was admitted into the Pennsylvania Hospital in 1876 with a compound fracture of the lower epiphysis, the epiphyseal fragment projecting some distance through the external wound.

FIG. 842.

Fracture of the shaft of the tibia.

Fractures which occur near the upper extremity of the bone and extend into the knee-joint are formidable injuries, and, if they are compound, seriously endanger the limb and the life of the patient. A fracture may pass through the tibia even above its articulation with the fibula. When the bone is broken at the lower end we may expect to find the fibula also fractured.

Fracture of the inner malleolus is not a very common accident. The process may be broken in three ways,—transversely near the tip; on a level with the articular surface of the astragalus; and obliquely, the fracture beginning in the shaft above, running downward and outward or inward, and detaching the process at the angle of union with the articular surface of the tibia. (Fig. 843.) When the tibia alone is broken, the direction of the fracture is—approximately, at least—transverse.

FIG. 843.

Fractured malleoli and lower end of the tibia.

CAUSES.—These are, in most instances, such as act directly, as a forcible blow, the kick of a horse, or the passage of a wheel. Those which operate indirectly, as in falls upon the feet, are apt to involve both bones. Proudfoot‖ gives a case of fracture of the tibia within the uterus from, it was supposed, severe pressure on the abdomen about the sixth month of pregnancy. The malleolus may be broken by forcible abduction or adduction of the foot.

SYMPTOMS.—As there is often little, if any, displacement, a careful examination is necessary to discover the lesion. Persons have been able to walk with a broken tibia. There is usually persistent pain, aggravated on pressure, and, after a time, discoloration. Some inequality may be detected by carefully running the fingers over the spine and the subcutaneous surface of the bone; also by grasping the bone above and below the suspected seat of injury and forcibly pressing the parts in opposite directions, motion and perhaps crepitus may be discovered. When the fracture is near the ankle, the lower fragment will obey the motions of the foot, and may, by acting upon the latter, be forced backward, forward, outward, or inward, giving rise to marked deformity. The same is true in fractures near the upper end of the bone: the lower fragment may be carried outward and backward, from the movable nature of the superior tibio-fibular articulation. The line of fracture is generally from within outward and from

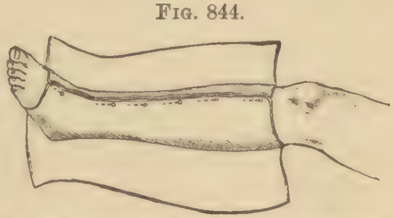
* Quain's Medical Journal, August 31, 1867.
† London Pathological Society's Transactions, vol. xiii. p. 187.
‡ New York Journal of Medicine, November, 1865.
§ Hamilton on Fractures, etc., p. 446.
‖ Boston Medical and Surgical Journal, vol. xxxv., 1846,—quoted by Hamilton.

below upward, a direction exceedingly favorable to lateral displacement of the bone. If the fracture is at the upper end of the bone and extends into the joint, there will be a large effusion into the articulation. When the malleolus is broken, there may be no displacement, the fragments being kept together by the strong fibrous investment which is spread over its surface, yet its mobility can be detected by pressure. Should the ligamentous expansion be completely ruptured, the lower fragment will sink down, and the distance between the process and the bone from which it is broken will be increased by abducting the foot, in consequence of the traction made on the internal lateral ligament. The chief symptom denotive of a separation of the lower epiphysis is said by R. Smith to be this,—"that the internal malleolus preserves its natural relations to the foot, but not to the leg or the outer ankle." The accident may also in this way be distinguished from luxation anteriorly of the inferior end of the tibia, in which injury the malleoli maintain their proper relations to the leg, but not to the foot. Professor Quain remarks that it may be distinguished from a fracture at the lower end of the bone "by the absence of a sharp, irregular edge, and by its smooth, rugous feel."

Prognosis.—In simple fracture of the shaft of the tibia, union occurs without apparent shortening, and generally with very trifling, if any, deformity. If the knee- or ankle-joint is implicated, the danger of anchylosis, more or less complete, will be imminent. When the malleolus is detached, its union may be ligamentous.

Treatment.—When the fracture is in the shaft of the bone, the management of the case is very simple indeed. The limb should be placed in the fracture-box, after the manner of treating fractures of both bones, either with or without suspension; or it may be embraced on each side with binders' board, soaked in hot water, moulded to the sides of the leg and foot, and bound on with a roller. In the course of eight or ten days the inflammatory swelling will have subsided: the leg should then be done up in some form of the immovable appareil already described, and the patient be permitted to leave his couch, on crutches. It is useless to confine him to bed under such circumstances until the bone is consolidated. There is a form of the immovable dressing often used for these fractures, known as the Bavarian. Take two pieces of canton flannel or of blanket, the length of the leg, and more than wide enough to envelop its circumference. They should be cut so as to correspond to the outline of the leg and a part of the foot. Place one of these over the other, and sew them together in the middle: the seam answers to the back of the leg. The leg and foot being placed upon this, the inner layer of flannel is brought up and made fast by pins in front of the leg and on the dorsum of the foot. (Fig. 844.) The limb being placed in the proper position, equal parts of plaster and water should be mixed together, then poured thickly over the surface of the flannel next to the limb, and distributed properly with a spatula; after which the second piece of flannel is brought up about the leg, and the whole smoothly modeled to the parts by the hand of the surgeon. Before the plaster sets, the pins should be removed from the inner flannel, and a few strips of muslin tied about the leg to keep the dressing secure. When it is desired either to inspect the limb or to remove the dressing entirely, it is only necessary to untie the encircling pieces of muslin and draw the edges of the flannel asunder, when the two halves will fall apart, the back seam acting as a hinge. Any swelling of the limb is also accommodated by the presence of this hinge, and, consequently, the danger of undue pressure is obviated. The sides can again

Fig. 844.



Bavarian immovable splint,—the flannel applied before the plaster is poured on.

be brought together if desired, and are capable of giving the support with as much accuracy as when first applied. Should there be an exernal wound, an opening in the plaster and flannel can be made to correspond with it, and the dressing thus rendered applicable to a case of compound fracture.

Professor Gross speaks favorably of a tin case with a foot-piece, as being well suited to the treatment of all fractures of the tibia.

When the fracture involves the upper end of the bone and extends into the joint, local depletion and cold applications become necessary in order to prevent the evil effects of inflammation. Whether the joint is entered or not, the extended position is to be preferred, with the knee a little flexed, so that in the event of permanent stiffness resulting the leg will be in the best position for future usefulness. The movements of the thigh must also be controlled, for its condyles will serve to give support to the head of the tibia and prevent its displacement. The long fracture-box meets most perfectly the indications to be fulfilled in the treatment of this injury. A pillow should be laid upon it, with a moderately thick compress of flannel fixed behind the knee. Upon this the leg and thigh are to be placed, the foot secured to the foot-board, and the sides of the box brought up and tied with strips of muslin. If there is displacement by the lateral separation of the tibial tuberosities, or by the tilting forward of the upper fragment of the tibia when the lesion is below the tubercle, it will be necessary to mould a light piece of felt or of binders' board to the posterior part of the joint, extending four inches above and six inches below the fracture, and, after interposing a sufficient amount of cotton, to fasten the splint firmly with a roller, and then place the limb in the long fracture-box as before. When the internal malleolus is broken, we may employ either the short fracture-box or the side-splints of binders' board, taking care to maintain the foot at a little less than a right angle with the leg, neither inverted nor everted, and also to defend the surface of the leg and foot from pressure by sufficient padding. In five or six weeks all dressings should be laid aside. As early as the third week it is necessary to make gentle movements of the ankle and the knee, so as to establish the functions of these joints.

Fractures of the Fibula.

These fractures are about as frequent as are those of the tibia. They may take place at any part of the bone, but are most common at the lower third. By a reference to the table it will be seen that in 252 cases, 16 were in the upper, 26 in the middle, and 210 in the lower third. Although Dupuytren found that of the 207 cases which he collected over two-thirds were on the right side, yet the observation does not hold good of the 218 cases which appear in the table, 113 being on the right side and 105 on the left. The same author asserts that the ratio of fractures of the fibula to other fractures of the leg is as one to three, whilst the table makes it about three and a half. We further learn from the table that of 315 cases, 273 were in males and 42 in females.

The influence of age on the frequency of this fracture will appear as below:

Age.	No. of Fractures.
Under 10 years	9
From 10 to 20 years	32
" 20 to 30 "	58
" 30 to 40 "	107
" 40 to 50 "	60
" 50 to 60 "	37
" 60 to 70 "	10
" 70 to 80 "	2
Total	315

Malgaigne, in his collection of 109 cases, saw none below the age of fifteen.

CAUSES.—These fractures are produced both by direct and by indirect force, but by the former less commonly than by the latter. When produced by the first factor, as by a blow, the wheel of a wagon, or the kick of a horse, the fracture will usually be found at the point where the force is applied; but if from indirect force, the bone will give way with singular uniformity within the limits of the lower third, and generally within two and a half or three inches of the inferior extremity. In 200 instances of this fracture Dupuytren could trace only 20 to the effects of direct violence. The explanation is probably to be found in the sheltered position of the bone, its situation being such that no front or even antero-lateral blow upon the leg can reach it without first breaking the tibia.

FIG. 845.

Articular surface for the astragalus.

To understand the manner in which indirect force operates as a fracturing cause, we may refer for a moment to the nature of the articulation between the foot and the bones of the leg. The two malleoli, extending some distance below the articular surface of the tibia, form a deep recess, into which is received the astragalus as is a tenon into a mortise (Fig. 845), forming a hinge-joint, and practically only permitting the movements of flexion and extension. When a person falls directly upon the bottom of the foot, the latter not being inclined either inward or outward, the tibia alone must receive the weight of the body, and therefore the fibula escapes. When the force is applied to the inner or the outer margin of the foot, so as to force the latter into extreme adduction or abduction, the external malleolus is subjected to powerful pressure; in the first, or that of adduction, by the outer surface of the calcaneum, and in the second, or that of abduction, by the outer surface of both the astragalus and the os calcis, in which last position the internal lateral ligament is frequently ruptured, and the injury followed by a partial luxation of the ankle. The fracture, therefore, may take place, as was first pointed out by Boyer, in these two opposite ways. Dupuytren required for the production of the fracture by abduction the precedent laceration of the internal lateral ligament or the giving way of the internal malleolus, believing that until this took place the calcaneum could not press sufficiently hard to break the bone; and, further, that after such laceration the weight of the body is communicated to the leg in a changed line, that is, in the direction of the fibula rather than in that of the tibia. Maisonneuve* does not admit this explanation, believing neither in adduction nor in abduction as a means of producing fracture above the external malleolus, but in external rotation of the foot. This rotation of the foot internal as well as external doubtless does occur, but it is secondary to that of adduction or abduction, and follows from the form of the foot. When a person walking over an uneven surface loses his balance, and in the struggle to regain it the foot is suddenly forced into a state of adduction, the weight of the body is received upon its outer margin, the most prominent part of which corresponds to the metatarsal part of the little toe; thus the toes are forced inward, and rotation of the foot is produced. So also when in the mis-step the foot is abducted, the weight is thrown upon its inner border, the salient portion of which is the metatarso-phalangeal projection of the great toe, and external rotation of the foot occurs. The fracture then may follow violent twists of the foot, the sudden turning in or out of the ankle, or falls when the foot is wedged in between unyielding surfaces. It was in the last-mentioned way that Sir Astley Cooper broke his fibula.

* Maisonneuve's Researches into Fractures of the Fibula, Archives Générales de Médecine, February–April, 1840.

Symptoms.—It is not always an easy task to determine the existence of a fracture of the fibula, especially when it is situated above the lower third. Pain, swelling, discoloration, inability to rest the weight of the body on the foot, and mobility, with or without crepitus, when the bone is pressed in opposite directions above and below the suspected point of injury, are the signs of the injury. When the bone is broken within three inches of the ankle, the injury is known as *Pott's fracture*. There is usually no difficulty in recognizing a lesion of the fibula at any point in the lower third. Frequently the patient will be conscious of a distinct snap or sound produced by the yielding of the osseous fibres; some irregularity in the line of the bone may be discovered by the fingers passed over the surface; the foot, having lost the resistance of the external malleolus and often the check of the internal lateral or deltoid ligament in consequence of the laceration of the latter, is often found strongly abducted by the action of the peroneus longus and peroneus brevis muscles, and the internal ankle becomes unduly prominent. As a consequence of this position of the foot, the upper end of the lower fragment is carried inward towards the tibia (Fig. 846), producing a decided depression over the seat of fracture. The mobility of this fragment may be ascertained by alternately adducting and abducting the foot. The upper fragment may remain unchanged, or, as is more commonly the case, may be carried inward towards the tibia.

A singular difference of opinion exists among authors as to the frequency of displacement in these fractures. Hamilton found it present in all the cases which came under his observation except one; Dupuytren declares that it existed in nine-tenths of his patients; while Malgaigne* states that in fracture produced by abduction of the foot there is neither displacement, swelling, nor deviation of the foot. Ecchymosis is deemed a characteristic symptom, Malgaigne having never seen it in a sprain. I have seen this fracture occur without, but much oftener with, displacement, by whatever agency it may have been produced; and as to the declaration of Malgaigne that ecchymosis is not present after sprains of the ankle, I may say that I have seen it many times after such accidents. When the external malleolus is broken, the nature of the injury may be determined by grasping the process between the thumb and the fingers, when mobility and crepitus will be experienced.

Fig. 846.

Fracture at the lower fifth of the fibula, with the attendant deformity,—Pott's fracture.

Fig. 847.

Deformity after a badly-treated Pott's fracture.

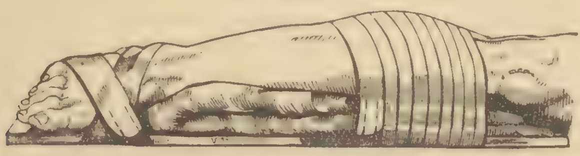
Prognosis.—Union of the fragments in fracture of the fibula occurs as quickly as in other bones of the skeleton, and usually without any noticeable deformity. Occasionally it happens that the external malleolus fails to unite by bone. In cases in which the internal lateral ligament is torn, and, as a consequence, eversion of the foot follows, there are well-grounded reasons for apprehension. More or less stiffness of the joint, together with an undue fullness of the internal ankle, is liable to follow. (Fig. 847.) When this internal projection of the tibia is great, the weight of the body is transmitted to the foot in such a manner as tends to increase the prominence, and, in bad cases, the skin has become inflamed and ulcerated over the internal malleolus.

Treatment.—The management of a case of fracture of the fibula, in any part above the lower fourth, is exceedingly simple. In a very docile patient

* Treatise on Fractures, Packard's trans., p. 654.

simple rest on a pillow, without any retentive apparatus, will answer, though, as a rule, it is better to apply two pieces of binders' board, well padded, along the sides of the limb, and fasten them with a spiral reversed roller. When the fracture is in the lower third and there is little displacement, the fracture-box will answer every purpose. The plantar surface of the foot should rest accurately against the foot-board, having the necessary padding between. If there is a tendency to eversion of the foot, as when the fracture is near the ankle and the inner ligament has been damaged, we have a special dressing which is much resorted to,—that of Dupuytren,—and which, while it does not entirely fulfill all the indications demanded, does so better than any other at our command. The mode of preparing and applying it is as follows. Make a wedge-shaped pad, by taking a muslin bag nearly five inches wide, and long enough to extend from the inner condyle of the femur to the internal malleolus of the tibia; stuff it with cotton or oakum, so distributed that the lower end will be two and a half inches thicker than the upper end. Place this along the inner side of the leg, the thick end over the malleolus, and upon it lay a wooden splint extending from the knee to a short distance below the foot. A bandage is next passed round the limb below the knee, making fast the upper end of the splint, and a second roller, in the form of the figure-of-eight about the ankle, secures its lower end, and at the same time draws the

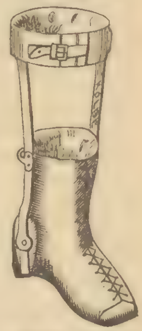
FIG. 848.



Dupuytren splint applied.

foot to the splint (Fig. 848); in other words, it brings the foot from a state of abduction to one of adduction, which tends to force out, in some degree, the upper end of the lower fragment. The disposition of the roller at the ankle should be such as not to rise higher than the external malleolus, otherwise it will prevent the lower fragment from turning out. It is scarcely necessary to say that the turns of the upper roller must not descend too low, as they would tend to force the superior fragment towards the tibia. During the use of the splint the internal malleolus must be carefully watched, as the pressure may induce inflammation and ulceration. Generally after six or eight days the dressing can be laid aside and the fracture-box substituted. After the lapse of twenty-five or thirty days, passive motion must be commenced at the ankle, though the patient should not be allowed to rest the weight of the body upon the foot for six or seven weeks. Badly-treated cases of this kind will be seen where, in consequence of the eversion of the foot and the corresponding prominence of the internal malleolus, not only is the ankle exceedingly weak, but the distortion is also progressive. For such cases a shoe, with a splint attached (Fig. 849), will give great support and comfort.

FIG. 849.



Splint for support of the ankle after fracture with deformity.

Compound Fractures of the Bones of the Leg.

These injuries are very common, much more so than compound fractures of other bones. By reference to the table it will be seen that of 315 fractures of the tibia, 49 were compound and compound comminuted; of 315 fractures of the fibula, 14 were compound and compound comminuted; and of 1074 fractures of both bones, 366 were compound and compound commi-

nuted. Taking the aggregate of all the fractures of the bones of the leg.—1704,—no less than 429 were of the above character.

Causes.—The greater proportion of these injuries which come into our hospitals result from the kicks of vicious horses, from railroad accidents, or in consequence of the limbs being caught in the machinery of manufactories or under falling walls.

Treatment.—The mode of managing the external wound will depend on the manner in which it has been produced. When caused by the sharp point of one of the fragments, or by some sharp vulnerating body, it should be sponged with carbolated water, and the edges drawn together by an adhesive strip, or by silver sutures. The air may be excluded by adding a little flour and white of egg to the oozing blood, the effect of which will be to form a firm crust or scab. Collodion and silk gauze are sometimes used for the purpose. When the external wound is formed subsequent to the fracture, in consequence of the pressure of the displaced fragments from within, or from severe contusion of the parts inducing ulceration of the skin and subcutaneous tissue, quick union cannot be expected, and consequently it is only necessary to cover the parts with lint saturated with carbolic acid and olive oil.

If the ends of the broken bone are found protruding through the external wound, their reposition should be attempted, either by flexing the leg so as to remove all muscular resistance, and at the same time pressing the pieces into place, or by extension and counter-extension. Dilating or stretching the external opening by means of retractors will often favor the reduction. Should these efforts prove unsuccessful, it may become necessary to enlarge the wound, and, in some instances, to remove with the saw the sharp end of one or both fragments. After the adjustment has been effected, the parts should be treated with the antiseptic spray, and the sides of the opening approximated by metallic sutures and sealed by the air-tight crust previously mentioned.

Still graver cases will be met with, in which the soft parts are extensively damaged and the bone or bones comminuted, yet the vessels remain uninjured. These, though serious, are not necessarily hopeless cases, especially if the subject is young, or a person possessing a good constitution. All loose or detached pieces of bone should be removed, the parts thoroughly cleansed and sponged, and the wound covered with lint saturated with carbolic acid and sweet oil. There should be no attempt at sealing up the opening; its closure would only serve to prevent the escape of purulent and other discharges, the retention of which must necessarily damage both the soft parts and the bone.

The next step consists in placing the limb upon a pillow in the fracture-box, as in the treatment of an ordinary simple fracture. The surgeon should never relax his vigilance for one moment. He must see that no abscess which is liable to form after such an injury is overlooked, and on the earliest evidence of suppuration should open the wound, or, if the pus collects at some point more remote, evacuate it at once with the bistoury. Whenever suppuration begins, the pillow should be removed from the box and its place supplied by bran, in which article we have not only the best means of imparting an evenly-distributed pressure to the limb, but also a material admirably suited to absorb and retain both the discharges and their odors.

When the suppuration is overpast, the bran may again be exchanged for the pillow if desired.

In still more intense degrees of complicated fractures of the leg, those, for example, caused by railroad violence or various kinds of machinery, where the bones are ground into pieces, the soft parts bruised, lacerated, and torn into shreds, the vessels and nerves destroyed, and the limb cold and pulseless, the duty of the surgeon is clear: amputation is the only resort, and should be done as soon as the patient has recovered sufficiently from the shock to endure the operation.

Another condition is occasionally witnessed, in which, in addition to com-

minution of the bones, there is a pulpification of all the parts below the skin, the latter remaining unbroken, or having only the cuticle detached in spots. After a shorter or longer time, depending on the degree of injury sustained by the blood-vessels, mortification will set in, rendering amputation necessary. In a case of this kind which I once saw, the sloughing was delayed for ten days, in consequence, I suppose, of the cavities of the vessels becoming slowly occluded by emboli.

Hemorrhage.—In compound fractures we meet with two kinds of bleeding—venous and arterial. The first may continue to ooze or flow for some time, even for days, from the external opening. Cold applications to the parts, and the elevation of the limb after it is dressed, will generally control it. The practice of binding on a compress, especially if the wound is large, is to be deprecated, as the blood finds its way among the components of the limb, stuffing the muscles and provoking suppuration. Arterial bleeding is of more importance. If it comes from one of the tibials and the fracture is at the lower third, the vessels should be sought for by incision or enlargement of the wound, and tied; if at the upper part of the leg and the flow is persistent, we have but one resort, and that is amputation.

Beset as these complicated cases are with the hazards of erysipelas, pyæmia, hectic, exhausting suppuration, necrosis, and vicious position of the broken portions of bone, their management demands constant and untiring attention to details, as well as the exercise of mature judgment. Pressure inducing excoriation and sloughing of the heel and other parts must be watched; carbolated and other lotions must be thrown into the suppurating cavity; laudanum and lead-water applied over inflamed surfaces; incisions made to evacuate abscesses; pressure shifted from place to place, to prevent accumulation of inflammatory products; dead fragments of bone removed; a proper diet administered, with tonics to sustain the body through an ordeal of exhausting suppuration, and anodynes to alleviate pain and to procure rest: all these are matters which will require attention. After the union has taken place, there will usually be stiffness of the ankle- and perhaps of the knee-joint, with much induration and thickening of the soft parts of the leg. This condition will require for its removal, motion, water douches, stimulating frictions, and well-applied pressure by the roller.

In many cases of these fractures of the leg, deformity will follow,—indeed, is unavoidable, even under the most skillful management.

Fractures of the Bones of the Foot.

Simple fractures of the bones of the foot are not common. Persons in falling from a height not unfrequently alight upon the feet, yet the bones of the leg are more likely to sustain the injury than are those of the tarsus or of the metatarsus. The explanation of this immunity from injury must be sought for in the abundance of cancellated tissue which they possess, in their irregularity of form, in their numerous articulations, and in the slight sliding movement which they are capable of performing on one another, thus distributing and neutralizing the momentum of forces. Compound comminuted fractures of these bones are common, and are generally attended by such extensive destruction of the soft parts, from the crushing nature of the violence which produces them, that the foot is hopelessly disorganized in its totality and will demand removal.

These fractures are divided into those of the *tarsus*, of the *metatarsus*, and of the *phalanges*. By reference to the table, it will be found that in 8667 fractures, 172 involved the bones of the foot, and were distributed as follows:

Fractures of the astragalus, 7, of the calcaneum, 14, of the other bones of the tarsus, 25,—making a total of 46; fractures of the bones of the metatarsus, 26; of the phalanges, 9; unclassified, 91: the total being 172. Of this number, no less than 77 were compound and compound comminuted fractures.

The injury is almost peculiar to males. Of the 120 cases classified, 118 were in males and only 2 in females. The largest number occurred between the ages of twenty and thirty, and amputation was performed forty-four times,—an evidence of the extensive damage sustained by the structures of the foot. The mortality following these accidents is shown by the fact that 23 out of the 172 cases died.

Fractures of the Astragalus.—This bone, being located between the malleoli, is less exposed than the other pieces of the tarsus, and will often escape injury when the latter are extensively broken. Being interposed between the os calcis and the tibia, it is placed in the direct line of support of the body, so that the forces which reach it injuriously are transmitted through the calcaneum, and hence the latter bone is generally broken by falls in which the person strikes upon the feet. In nine cases out of ten collected by Dr. Monahan,* this was the manner in which the fracture occurred.

The direction of the fracture may be longitudinal, transverse, or horizontal. In the case recorded by M. Tavignot† it was both longitudinal and transverse. Lonsdale‡ speaks of having seen a case in which the bone was broken in at least two directions. Malgaigne possessed a specimen of a transverse fracture;§ and M. Rognetta has seen one of multiple fracture. Sir Astley Cooper‖ mentions a very singular case, in which the line of separation was horizontal. Mr. Erichsen¶ has seen two cases of this fracture without the implication of other bones.

Symptoms.—If there is no displacement of the fragments, the recognition of fracture of the astragalus is a very difficult—often, indeed, an impossible—task; and this is true also of the other pieces of the tarsus. Hence some of these fractures have been discovered only by dissections. Bound as these bones are by strong and variously-disposed ligaments, and presenting so many articular faces, much displacement need not be expected. Moreover, when the swelling consequent upon the injury is considered, the difficulties of the diagnosis are further increased. Persistent pain, inability to bear pressure upon the foot, rapid swelling, and crepitus produced by flexing, extending, or abducting and adducting the foot, would constitute ground for predicating the existence of this fracture. When, however, displacement is present, the diagnosis is in some measure cleared up.

Mr. Erichsen could distinctly feel the crepitus, and also the line of separation, in one of his cases. The other was a compound fracture, and the posterior fragment lay in the wound; the anterior fragment was comminuted.

Treatment.—When the skin is unbroken and there is no displacement, the treatment consists in flexing the leg and placing it on its outer side in a splint of binders' board, moulded to receive both the leg and the foot, or simply in laying the leg upon a pillow, in the same position. Cold applications of lead-water and laudanum should be used to control the inflammation, swelling, and pain. After the swelling has subsided, an immovable dressing of starch, silicate of soda, or plaster should be applied to the foot and ankle and to a portion of the leg, in order to insure quiet. When displacement exists without the skin being broken, an attempt should be made to press the fragment back into place. Dr. Ashhurst was able to do so in a case which he has reported.** Norris made a similar attempt, but failed.

The propriety of reposition, even when no external wound is present, has been questioned by Hamilton and others in cases where the displacement is great. We are not in possession, however, of sufficient data to speak dog-

* Hamilton's Treatise on Fractures, etc., 5th ed., p. 502.
† Bulletin de la Société Anatomique, 1843, p. 170. From Malgaigne.
‡ On Fractures, p. 531.
§ Treatise on Fractures, p. 666, Packard's trans.
‖ Sir Astley Cooper on Dislocations, by Bransby Cooper, p. 290.
¶ Surgery, vol. i. p. 388.
** American Journal of the Medical Sciences, April, 1862.

matically upon this subject. In my own judgment, no efforts should be spared to restore the fragments to their proper position, and only in the event of failure to effect reduction should the excision of the bone be adopted. When its removal is decided upon, the entire astragalus should be extracted, and not the detached or loose portion. In Dr. Norris's case, to which allusion has been made, only the displaced fragment was taken away, the part remaining in position next to the tibia being allowed to remain; it became carious, and, though it was afterwards extracted, the disease had extended to the articular surface of the tibia and the fibula and to all the pieces of the tarsus, requiring finally the amputation of the foot, from which the patient ultimately died.

When the fracture is a compound one accompanied by displacement, there can be no doubt about the propriety of excision.

Mr. Erichsen, in his second case, a man thirty years of age, who had broken the astragalus by a fall upon the feet, removed, by enlarging the external wound, the displaced fragment, which lay posteriorly, between the external malleolus and the tendo Achillis. The patient died of pyæmia, and the after-examination showed that the anterior fragment had been broken into seven pieces, and yet, notwithstanding this comminution, no crepitus could be felt. Mr. Bryant* speaks of two cases of this fracture which came under his care, both compound. In one, the anterior portion of the bone was broken off and forced entirely out through the external wound; in the other, the bone was broken into fragments and extruded below the external ankle. In the former, amputation was done; in the latter, the patient recovered without an operation, though the joint was left permanently stiff.

Fractures of the Os Calcis.—This bone is particularly exposed to injury from falls upon the feet, notwithstanding the thick padding of fat with which it is covered. It is liable to be broken by force directly applied to its plantar surface, which may rive it into fragments. Malgaigne was the first to recognize this variety of fracture, as far back as 1843. It is more especially the subastragaloid part of the bone which suffers. Another variety involves the post-astragaloid or, commonly speaking, the heel portion (Fig. 850), and has been generally attributed to muscular action; oftener, however, in my judgment, it is caused by direct force applied to the heel when the limb is advanced, in which case the fracturing violence would act upon the posterior portion of the bone. The two cases, however, related by Sir Astley Cooper† would seem to render the fracture explicable on no other theory than that of muscular action. The one was a lady who, while walking in a field, stumbled, and in the violent effort to recover herself broke the bone; the other was a lady in whom the fracture was produced by the muscular effort made to save herself from falling down a flight of stairs. The cases related by Petit and Desault‡ seem to be of the same kind. In these the bone was broken in the act of regaining the equilibrium after making a false step.

FIG. 850.

Comminuted fracture of the post-astragaloid portion of the os calcis.

Mr. Anningson, of Burnley, England, met with a fracture of the os calcis produced much in the same manner.§ A healthy woman, aged forty-two, in stepping from a store to the pavement, which was six inches lower, and forgetting that the two were not on the same level, was in the act of falling headlong, which she only prevented by an unusual muscular struggle, after which the leg was found dis-

* Surgery, p. 876.
† Sir Astley Cooper on Dislocations, by B. Cooper, p. 339.
‡ Malgaigne, Treatise on Fractures, Packard's trans., p. 667.
§ British Medical Journal, January 26, 1878.

abled. On examination, a fragment of bone was found two inches and a half above the heel, drawn up by the tendo Achillis, and with the skin tightly stretched over it. The piece was about one inch wide, and did not involve the entire depth of the calcaneum.

The exact situation of these fractures we have often no means of determining. It seems very improbable that a sound calcaneum—a bone so strong and thick—could be severed by muscular power alone, except by the detachment of a thin stratum immediately underneath the insertion of the tendo Achillis,—a supposition which has not escaped the notice of writers, —and I am not aware that the history of any case would disprove this statement.

Symptoms.—These differ according to the portion of the bone involved. If the subastragaloid portion is broken, the fracture is usually comminuted, and the fragments either settle down together or are driven into one another, in which event the vertical diameter or depth of the bone will be diminished, while its transverse diameter will be increased. The pain is severe, and greatly aggravated by the attempt to rest any weight on the foot. Malgaigne describes the swelling as being limited to the parts below the front of the ankle and the malleoli, and to the sole of the foot, none being present over the heel or in the space about the tendo Achillis.

The limitations of the swelling may be explained by the attachment of the lateral, the anterior, and the long calcaneo-cuboid ligaments. These, in a great measure, isolate the subastragaloid from the post-astragaloid portion of the bone. Too much stress, however, must not be placed on this symptom, as the swelling is not invariably confined to these limits. The swelling on the two sides differs; that beneath the outer malleolus is soft and unresisting, whilst that beneath the internal malleolus has but little depth, and is due more to the displaced lesser apophysis of the bone than to the effusion of serum. Crepitus may or may not be present, and is most readily produced by rotating the foot, by pressing the heel from side to side, or by holding the heel and flexing the ankle, as in the cases reported by Mr. Gascoyen* at St. Mary's Hospital. When the post-astragaloid or heel part of the bone is broken, there will be pain, swelling about the heel, mobility, and crepitus, and if the line of separation is near the insertion of the tendo Achillis, more or less displacement backward and upward will follow, caused by the action of the gastrocnemius and soleus. This displacement of the posterior fragment varies from a quarter of an inch to five inches. In all these cases of extreme drawing up of the posterior fragment, the fracture must be near the insertion of the tendo Achillis.

Prognosis.—Unfortunately, I am unable to make any deductions from the fractures of this bone recorded in our table, as only the general mortality of fractures of the bones of the foot was noticed in the source from which the material was drawn; but after examining those cases in which the results have been recorded, and where the fracture was situated in the post-astragaloid part and not comminuted, I find that recovery has generally taken place in from six to seven weeks, although the perfect use of the foot and ankle was not recovered until after a much later period. When the fracture involves the subastragaloid part, the case is far more serious, as being within the calcaneo-astragaloid articulation and generally attended with comminution. Even in a case reported by M. Voillemier, in which both calcanea were broken in this part, the patient recovered.

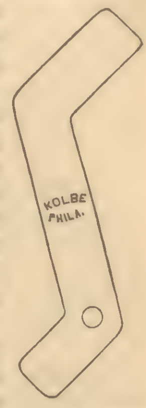
The three cases of Mr. Gascoyen, already alluded to, terminated favorably, as did also the cases of Béringuier and Moré, given by Malgaigne. The recovery will be slow, and the patient may expect to suffer for a long time with severe pains in the sole of the foot, together with a stiff and swollen ankle.

Treatment.—When the fracture is in the posterior part of the bone, and attended with displacement, the detached fragment being drawn upward

* Medico-Chirurgical Transactions, vol. xxxix., 1856.

by the muscles constituting the calf of the leg, the latter should be flexed upon the thigh and the foot extended upon the leg. Conjointly, these two postures furnish us with the best possible position for the limb. The displaced fragment should next be drawn down into place and retained by applying above it the centre of a strip of adhesive plaster, bringing the ends down on each side of the heel to the sole of the foot, where they are to be crossed and finally made fast over the instep.

Fig. 851.



Double angular or Pott's splint, modified for fracture of the calcaneum.

The limb should now be laid on its outside upon a well-padded double angular splint (Fig. 851), having the piece which supports the foot cut at such an angle as will conform to the extended position. To this the limb should be fixed by a few adhesive strips at intervals of four inches, or by a roller carried from the foot four or five inches above the knee. Should no displacement be present, position alone is all that is required. After the swelling subsides, a starch, plaster, or silicate-of-soda dressing should be applied.

Thillaye devised for the treatment of this fracture a slipper with a leather strap attached to its heel, and which was to be fastened to a circular band surrounding the lower part of the thigh. Monro fastened the slipper to a garter laced about the calf of the leg. (Fig. 852.) He also placed a splint in front of the leg and over the dorsum of the foot, and bound it in place with a roller. (Fig. 853.) Professor Gross advises the use of a tin splint, well padded, fitted to the form of the limb, and extending from the middle of the anterior surface of the leg almost to the toes. Against all anterior splints it may be stated that extreme extension of the foot becomes very difficult to endure, neither is it essential to the adjustment.

Fig. 852.

Monro's modification of Thillaye's apparatus for fracture of the calcaneum.

Fig. 853.

Monro's dressing for fracture of the os calcis.

The division of the tendo Achillis would naturally suggest itself in the event of other measures proving inadequate to restore the displaced bone to its proper position; but as the fragment depends for its vascular supply on

its connection with this tendon, such an operation might, as has been suggested by Ammington, be followed by the death of the piece.

When the fracture is subastragaloid, there is no necessity for splints; the leg should be placed in an easy position and the inflammatory symptoms met by the assiduous application of cold lotions of lead-water and laudanum. After the danger from this source is past and the swelling disappears, the immovable dressing may be applied and the patient allowed to go about on crutches. The surgeon must not neglect, at as early a day as possible, to make those movements which are required to prevent the probable anchylosis of the ankle-joint.

Though such an accident has been said to occur, there are, I believe, no well-authenticated cases of fracture of the *tuberosities of the calcaneum* caused by muscular action. It is impossible to conceive of one of these strong processes being broken away by the action of muscles like the abductor of the great toe or the little toe, or by the contraction of the short flexor of the digits.

Fracture of the Sustentaculum Tali.—This injury may occur singly, or it may be associated with a comminuted fracture of the subastragaloid portion of the calcaneum, and no doubt sometimes exists without being detected.

Causes.—There are two ways in which the injury may be produced: first, by a fall directly upon the heel part of the foot, forcibly driving together the os calcis and the astragalus; secondly, by force applied to the outer side of the foot when the latter is strongly adducted. The latter manner of producing this lesion was first pointed out by Dr. Abel.* The external lateral ligament may be broken either before the process of bone gives way, or immediately after the accident: if before, the force transmitted to the sustentaculum tali will be immediate and intense.

Symptoms.—The signs of an uncomplicated fracture of the sustentaculum tali are, severe pain experienced on the inner side of the ankle and below the internal malleolus, and extreme abduction of the foot as soon as the patient attempts to rest it upon the ground. The heel will also be shortened; while crepitus, that most decisive of all signs of fracture, will generally be absent.

Differential Diagnosis.—This injury may be confounded with comminution of the calcaneum, with Pott's fracture of the fibula, and with fracture of the internal malleolus.†

In cases of comminuted fracture of the os calcis, both malleoli sink below the normal level, the pain is diffused or general, and the heel may be lengthened; whereas in fracture of the sustentaculum tali the depression affects chiefly the inner malleolus, the heel is shortened, and the pain is limited for the most part to the inner side of the ankle.

In Pott's fracture, preternatural mobility and crepitation are prominent symptoms of the injury, but not so in fractures of the sustentaculum tali, since, in the latter, the disability of the foot and the severity of the pain are unusually great.

In fractures of the internal malleolus, the inversion and occasional eversion of the foot, together with the locality of the pain, simulate a like injury of the process under consideration; but on a careful investigation it will be found that in the former the pain is higher up, the malleolus is more prominent, the mobility is much greater, and the abduction of the foot is greater.

Treatment.—The treatment consists in bringing the foot from its state of abduction to one of moderate adduction, and maintaining it in that position by the use of the Dupuytren splint; or, if the inner ankle is too sensitive to endure with comfort the pressure of the wedge-shaped pad, this dressing can be substituted by the plaster roller, carried over the foot, ankle, and a part of the leg, while the foot is kept in the proper position until the gypsum sets.

The degree of disability following the injury will depend on the amount

* Arch. für Klin. Chirurg.

† Dr. B. von Langenbeck, B. xx., 1878.

of displacement of the flexor tendons, which pass beneath the sustentaculum tali, and also on the degree of crushing to which the calcaneum itself has been subjected: except when these are exaggerated, the prognosis is not unfavorable.

Fractures of the Metatarsal Bones.

These fractures are generally the result of direct and crushing violence. They cannot be considered common accidents. Only three or four cases occurred at the Hôtel-Dieu, Paris, during a period of eleven years. Twenty-six cases were admitted into the Pennsylvania Hospital during a period of forty-four years. As far as the individual pieces broken have been noted, the metatarsal bone of the great toe was most frequently involved, namely, seven times; and next to this, the fifth or metatarsal bone of the little toe, four times. The displacement which follows usually consists in the depression of the phalangeal fragment.

In the simplest form of these fractures—that is, where they are unattended by laceration and crushing—the prognosis is not unfavorable. Even in compound fractures the repair is often very rapid. Hamilton has seen the metatarsal bone of the little toe severed with an axe and yet healed in thirty days. Delamotte gives a case in which the first four metatarsals were divided in a similar manner, which yet recovered in forty days.

TREATMENT.—A piece of binders' board should be moulded to the posterior part of the leg and to the sole of the foot, the latter being nearly at a right angle with the leg. This splint must be well padded, and all the inequalities filled with oakum or cotton, so as to maintain the natural form of the sole of the foot. Any displacement should be corrected by such manipulations as ordinary skill would suggest, after which the splint should be secured to the foot and leg with a roller.

Fractures of the Phalanges of the Toes.

It is very rare to meet with a simple case of fracture of one of these phalanges; generally the injury is attended with so much damage to the other parts as to necessitate amputation. The great toe is the one commonly broken, and, as has been observed by Lonsdale and others, its fracture is often attended with unusually severe symptoms, such as swelling of the foot, and even of the entire limb, glandular enlargements, multiple abscesses, and exhausting hectic symptoms. This is indeed true of other injuries affecting this part of the foot. Malgaigne states that of forty-three amputations of the great toe for injuries, in the different hospitals of Paris, seven proved fatal. When the foot is broken, it is usually due to some weight falling with crushing force upon it, and the great toe, being most prominent, receives the principal injury. Mobility and crepitus indicate the nature of the case, and the simplest plan of treatment is to apply a starch or silicate-of-soda dressing; or a piece of light wood, or of binders' board, well padded, may be secured with a roller to the plantar surface of the affected toe, extending back under the sole of the foot, so as to give fixation to the metatarso-phalangeal joint.

DISEASES OF THE BONES.

The osseous system is liable to morbid processes similar to those which affect the soft parts, modified in some degree by the presence of the inorganic salts which give solidity and hardness of texture to the skeleton. The anatomical construction of a bone, particularly one belonging to the class of long bones, furnishes a very natural basis for the division of its inflammatory affections. A bone is surrounded externally by a fibro-vascular membrane,—the periosteum,—and internally incloses the endosteum or medullary membrane, prolongations of which extend into the cancellated tissue around the medullary canal.

The inflammatory diseases are the following:

1. *Periostitis*, an inflammation of the periosteum or external investing membrane. 2. *Osteitis*, an inflammation of the bone proper. 3. *Endosteitis*, an inflammation of the medullary membrane. 4. *Osteomyelitis*, an inflammation of both the medullary membrane and the surrounding bone, particularly of its cancellated structure. The three structures, viz., periosteum, bone, and endosteum, are, in a certain sense, one,—that is, the vital connection or the continuity of structure is so intimate that disease in one part may readily extend to the others, thus involving the bone in its entirety. This statement does not apply with equal force to all parts of the bone at all periods of life; the cartilage which separates the epiphysis from the diaphysis appears to render the blood-vessel supply of the one independent of the other. Thus, in coxalgia, and in the like disease of the knee-joint, the inflammation clings to the articular ends of the bone, the shaft remaining unaffected; and in caries located near the end of the shaft, the disease shows little tendency to implicate the joint.

Bone is liable to other diseases, which may or may not originate in a pre-existing inflammatory condition, and which are the result of a constitutional state, as scrofula, syphilis, tubercle, rheumatism, cancer, osteomalacia, rickets, hypertrophy, and atrophy.

General Anatomical Considerations.—The bones consist of an external compact layer and an internal spongy or cancellated tissue; and, in the case of the long bones, of a medullary canal in the centre. They are surrounded by a laminated periosteum, the fibres of which are closely interwoven. This structure is connected to the bone which it invests by filamentous prolongations of its own tissue and by blood-vessels, which ramify in the superficial layer of the periosteum and afterwards pass through the deeper laminæ. Through all portions of the bone run canals, called Haversian canals. These open outward upon its surface, and also inward towards the medullary cavity, and are lined by a small amount of connective tissue, which serves to connect the vessels to the walls in which they lie. On the inside of the medullary cavity there is a delicate fibro-vascular membrane,—the endosteum,—which supports the medulla, and the divisions of which penetrate into the cells of the spongy tissue. The vessels which ramify through the Haversian canals, and the connective tissue which lines the latter, are continuous with the periosteum and its vessels and with the endosteum and its vessels.

Except as it may be slightly modified by the presence of inorganic salts, inflammation of bone does not differ in its phenomena from the same process elsewhere. It has the same stages of determination, congestion, and transudation; it is attended by like effusions of serum, lymph, leucocytes, blood, or pus; it may be followed by induration (*sclerosis*), or by softening and atrophy; and it may result in ulceration (*caries*), or in mortification (*necrosis*).

Periostitis.

Inflammation of the periosteum appears under two different forms, the chronic and the acute, or the *circumscribed* and the *diffused*.

It is rarely the case that the inflammation is confined strictly to the periosteum; it involves also a portion of the compact tissue of the bone with which it is connected, giving rise to an osteitis, or, by extension into the medulla, may end in osteomyelitis.

When the disease arises from constitutional conditions, not all the bones of the skeleton are alike liable to be attacked. Syphilitic periostitis generally elects the tibia, the ulna, the clavicle, and the cranial bones.

When the subjects of the disease are children with a strumous diathesis, the tibia, the femur, the radius, and the ulna are attacked in preference to other bones. When the disease begins near the articular ends of bones, it should be always regarded with anxiety, as the continuity of the periosteum with the synovial membrane and with the ligaments of a joint will favor the extension of the morbid action to the latter.

Causes.—Inflammation may be excited by external injury from blows, fractures, gunshot and other wounds, and I have no doubt is frequently induced by violent contraction of the tendons which are implanted upon the membrane. The same influence is active in the production of osteitis. Periostitis may also be excited by a progressive osteitis. Among the internal constitutional causes producing periostitis are scrofula, syphilis, gout, and rheumatism. It may arise from exposure to the action of certain medicinal substances, as mercury and the fumes of phosphorus. Occasionally I have seen periostitis produced by disease of the kidneys.

Symptoms.—Circumscribed periostitis or chronic periostitis is characterized by local tenderness, pain, and swelling, without any very marked redness at first; the pain is usually increased at night, often attaining great severity when the patient becomes warm in bed. The swelling is not abruptly defined, but fades off into the adjoining parts, and is round in form.

In other instances the symptoms pursue a more acute course. The skin is discolored, the tenderness becomes exquisite, and the entire limb is disabled, accompanied by more or less constitutional disturbance.

When the periostitis is due to constitutional influences, the local symptoms are somewhat modified. If of rheumatic origin, the pain will often change or move from place to place, the articulations suffering most; the integument becomes white and glossy,—rarely red,—and thickened. There will be also signs of defective blood depuration, manifested in the abundance of urates which appear in the urine, and in a peculiar sour perspiration which collects on the skin.

Pathology.—The pathological changes in circumscribed periostitis consist of an inflammatory transudation into both the superficial and the deeper strata of the membrane, forming an enlargement, sometimes termed a *node*. This transudation, consisting of fibrous lymph and leucocytes, serves to form a prominence over the surface of the bone. After this first effect, the inflammatory product will undergo one of three changes: first, it may be gradually absorbed, as are similar infiltrations elsewhere; secondly, from contact with the bone, it may undergo ossification, much in the same manner as in fracture, in which event there remains a corresponding enlargement or permanent thickening of the bone; thirdly, suppuration may follow, in which case a partial death of the underlying bone takes place, leaving a superficial bone-ulcer, which is repaired by granulation tissue.

When the disease is the result of syphilis, the destiny of the node may be approximately determined by the period at which it makes its appearance. If in the advanced stage of the constitutional vice, the tendency will be to suppuration, and as a consequence a portion of the bone will die.

Treatment.—When the periostitis arises from a traumatic cause, the symptoms will be of an acute character, and must be met promptly by elevation of the part, and the application of leeches, followed by evaporating lotions of lead-water and laudanum, and later by a fly-blister over the affected parts. The bowels must be freely acted upon, and the diet restricted to light farinaceous articles of food. Pain is best controlled by morphia.

Should the use of these remedies fail to arrest the disease, and the pain and swelling continue to increase, a free subcutaneous division of the soft tissues entirely through the periosteum should be made, after which the parts may be covered with a flaxseed-meal poultice. The effect of this procedure will be to relieve the pain and to rescue the bone from caries or necrosis.

When the periostitis has a rheumatic or a syphilitic origin, nothing answers so good a purpose as the free use of the iodide of potash, administered in doses varying from five to twenty grains three or four times a day, largely diluted with water. This remedy not only arrests the severe nocturnal exacerbations of pain, but also tends to bring about the resolution of the inflammatory products. Until the patient is brought under the influence of the remedy, the suffering must be relieved by full doses of opium, morphia, or laudanum.

The induration of the soft parts over the bone, which is due to a peripheral extension of the inflammation from the periosteum, is best managed by the application of the tincture of iodine, or by *massage*, followed by firm pressure with a roller.

Acute or Diffused Periostitis is often a most formidable disease. It is rarely seen after twenty-five years of age, being generally met with between the tenth and the fifteenth year of life, and it affects boys oftener than girls. Although it is said occasionally to arise from local violence, yet such cases must be very rare. Antecedent to such a condition, there is either a strumous diathesis, or else a depraved state of the general system supervening on some exhausting fever from which the patient has suffered. The long bones are in most instances the ones attacked, and of these the femur and the tibia most commonly suffer.

The progress of the disease is often exceedingly rapid.

Symptoms.—A diffused swelling makes its appearance, which, after a time, becomes red, pits on pressure, is painful, and is either preceded or accompanied by shiverings, fever, and loss of appetite. The limb becomes exceedingly sensitive and helpless. The swelling may extend over the whole length or only a portion of the thigh or the leg, though, as a rule, it does not include the joints. The diffused nature of the swelling is well calculated to mislead, and often irreparable damage is done to the bone before the true nature of the disease is even suspected.

Diagnosis.—The real character of the complaint may be deduced from the following circumstances: first, the age of the patient, usually under twelve years, and its having either the history of a previous injury, received six or eight days before the invasion of the attack, or the well-expressed indications of a strumous state of the system; secondly, the presence of a diffused swelling and of pain before any discoloration of the skin is discovered, and the limitation of the swelling, the latter rarely extending beyond a joint; thirdly, the presence often of an enlargement of the superficial veins of the limb, in consequence of the mechanical resistance offered to the circulation through the deeper trunks, of which the first are tributaries.

Pathology.—Diffused periostitis differs from the limited or chronic variety mainly in the acute character of the inflammation. There is at first both a subperiosteal and a periosteal transudation, consisting of serum, lymph, leucocytes, and red blood-corpuscles, which separate the periosteum from the bone, finally ending in the formation of pus. The suppuration may be limited to only a portion of the bone, or it may detach the membrane up and down as far the cartilage, separating the diaphysis from the epiphysis, beyond which the disease seldom extends, though in some instances it has been known to transcend these boundaries and implicate the joints. The effect of disturbing the blood-vessel connection between the bone and the periosteum is to destroy the firmness of the superficial fibres of the former, and finally to cause its complete death. The affection seldom appears in the severe form without the co-existence of osteomyelitis. In its

advanced stage the purulent products find their way through openings in the periosteum and spread through the surrounding tissues.

Prognosis.—In cases where the disease is quite limited, after the evacuation of the abscess, granulations may spring up from the periosteum, or if a superficial portion of the bone dies and becomes detached, from the osseous surface, and a sound cicatrix may be established. When there is extensive suppuration around the bone, the risk of purulent infection is very great; and when a considerable portion or the entire diaphysis of the bone becomes necrosed, the patient may finally perish from the prolonged suppuration which must continue until the dead shaft or the sequestrum can be removed, —the work necessarily of many months.

Treatment.—If the disease be recognized early, it is susceptible, in favorable cases, of resolution. For the accomplishment of this end the limb should be elevated and thoroughly painted with the tincture of iodine. This remedy has been extolled by Billroth, and certainly is a very efficient agent. It should be applied twice in the twelve hours of the day. The bowels should be briskly moved by a cathartic, and in thirty-six hours, if the swelling and pain do not begin to subside, the parts should be covered with a blister, over which may be laid a light flaxseed-meal poultice. The warmth of the latter hastens the action of the vesicant, which will most likely be well raised in six or seven hours. If in defiance of these measures the disease does not yield, and fluctuation can be ascertained, one or several incisions down to the bone should be made, so as to give a ready exit to the pus. To counteract the exhausting effects of the suppuration, quinine and iron must be administered, together with stimulants and the most concentrated nourishment. If the bone perishes, its removal should be effected at as early a period as possible, unless the patient labors under much febrile disturbance of the system, when it is better to delay operative interference until the circulation becomes more quiet. The reproduction of the bone may be expected, as the osteogenetic property of the periosteum of the contiguous bone is not permanently destroyed by the disease.

When the disease arises from constitutional syphilis or from rheumatism, full doses of the iodide of potash will be indicated. Such a course is generally sufficient to control the affection.

Osteitis and Caries.

Inflammation of bone may be either *superficial* or *deep;* that is, it may be confined to the external portions of either the long or the short bones, or may extend to their deeper, cancellated tissue, including, in the cylindrical class, also the medullary structure. The disease is usually chronic in its course, and is generally associated with periostitis, either primarily or secondarily.

Causes.—The causes are predisposing and exciting. Among the predisposing causes are scrofula, syphilis, and those blood-changes which are engendered by low forms of fever. Among the determining or exciting causes may be enumerated blows, strains, violent contraction of muscles, compound fractures, and exposure to a damp, cold atmosphere.

Symptoms.—One of the earliest signs of osteitis is pain. This may be very slight at first, but becomes more pronounced as the disease advances, especially when pressure is made over the affected part. After a time it becomes a deep-seated ache, boring or gnawing in its character, and generally much aggravated at night, or when the patient becomes warm in bed, or when the limb is rudely handled. Accompanying the pain is diffused swelling, which is of an œdematous nature, as shown by the indentations left in the soft parts when pressed upon with a finger. As these symptoms belong to periostitis, it is a difficult task to dissociate the two or to distinguish the one from the other; and if we could, the practical value of such knowledge would be of slight importance. It is very certain that neither can long exist separately without the other being involved in the

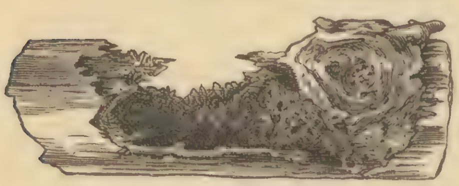
same trouble. The symptoms which indicate that the osseous tissue is implicated are the persistence of deep-seated boring pains, and long-continued alternations of improvement and relapses. When the inflammation is chiefly periosteal, it is usual to have the surface of the bone studded over with little masses of bone, or *osteophites*. The same condition will follow osteitis, though not at so early a period in the progress of the disease. (Fig. 854.)

FIG. 854.

Osteophites springing from the tibia and fibula and some of the bones of the tarsus, from osteitis.

Caries.—If the disease advances to ulceration or caries, the thickening around the bone becomes more noticeable, the superincumbent planes of tissue become infiltrated with inflammatory neoplasia, lymph, and leucocytes, giving rise both to induration and to structural alteration, the normal structures being replaced by connective and fat tissue. If the inflammation is circumscribed in circumference or in depth, or in both, the vitality of the portion involved will in all probability be destroyed, and it will either separate from the bone in the form of a scale (*exfoliation*) or in small particles. Coincident with these changes, and as preliminary to one of ejection, the soft parts over the affected portion of the bones become inflamed, and an abscess opens upon the surface. If a probe is now inserted into this opening, it will be brought into contact with either a movable fragment or with a rough and irregular surface of bare bone. The sensation imparted to the finger will be peculiar, and can scarcely fail to reveal what has occurred. When the affected part belongs to the short or irregular class of bones, instead of scales or crumbling particles being detached, the dead portion will often separate in a small shapeless mass. After the disengagement and expulsion of the disorganized fragments, a cavity remains, the surface of which consists of minute ridges and spiculæ of bone, presenting a rough, gnawed appearance, and constituting a bone or carious ulcer. (Fig. 855.) This ulcer is liable to all the complications which befall ulcers of the soft parts; that is, it may heal up spontaneously, it may extend in circumference and in depth, it may remain weak and indolent, without any tendency to repair, or it may be filled with a rank growth of granulation tissue, which will not only overtop the depression in the bone, but also protrude through the sinus in the soft parts.

FIG. 855.



Caries or ulcer of the tibia.

Caries often exists, followed by complete repair, without any external opening being formed. This is frequently witnessed in Pott's disease of the spine.

When the inflammation, instead of lingering in the superficial layers of bones, extends into the deeper or cancellated tissue, it forms internal or deep osteitis. The more abundant the cancelli, the greater will be the tendency of the disease to spread. Accordingly, we find that the bones of the carpus, the tarsus, the vertebral column, and the articulating ends of the long bones are most commonly affected.

PATHOLOGY.—The changes which take place within the hidden recesses of bone in simple inflammation are analogous in most respects to the phenomena which characterize a similar process in other tissues. The vessels lodged in the Haversian canals become over-distended with blood; a free transudation of liquid and cell-elements takes place into the scanty connect-

ive tissue between the vessels and their inclosing walls. Part of this perivascular connective tissue is converted into a soft jelly-like substance by the dissolution of its corpuscles, and possibly some of the latter may pass from a stable to an active state. Responsive to the presence of this fresh brood of wandering cells and fibrinous transudation, a change occurs in the walls of the Haversian canals, the lacunæ, and the canaliculi. They begin to enlarge, not by virtue of any elastic property, but probably from the solvent or eroding action of some constituent belonging to the inflammatory neoplasm acting upon the osseous salts and thus dissolving their connection with the organic matter of the bone. These walls become wider and perforated, the contiguous channels opening into one another, until the bone assumes somewhat the appearance of the open, porous condition of cancellated tissue. New vessels are developed and lie imbedded in the midst of the transudation, thus forming granulations, which grow in all directions into the vacuities left by the widened and porous remains of the Haversian canals. The continued proliferation of these granulations may destroy the bone for some distance around the focus of disease. In this work the bone-corpuscles take no part; the essence of the process concentrates in the changes which occur in the walls of the vessels and in the connective tissue which lies in the Haversian canals, the result of which is simply one of destruction to the bone without any power on the part of the latter to resist.

In this rapid enlargement of the vascular channels of bone in osteitis we have a beautiful illustration of the wonderful adaptation of tissues to meet extraordinary conditions. Considering the resistance and the small size of these canals, unless the change which has been described did follow, the vessels themselves would be so rapidly compressed by the infiltration as to destroy the life of the bone, causing extensive necrosis, for it must be remembered that any sudden swelling of a bone from inflammatory infiltration is impossible; especially is this so in the compact portions of bone. The extension of caries, like that of ulceration in the soft parts, is limited, in favorable cases, by an inflammatory infiltration into the sound bone immediately around the diseased portion. This fills up the cancelli of the osseous tissue, and at the same time dissolves the connection between the diseased and the sound bone, the former breaking up into small particles, which are either discharged through an external opening, when such exists, or, in the absence of this opening, undergo interstitial absorption. The discharges resulting from caries of bone are composed of the lime salts, mingled with pus, blood, globules of oil, and minute particles of osseous tissue.

In superficial caries, with an external opening, when the disease is arrested and the necrosed portions have been detached and expelled, the repair is effected by an abundant production of granulation tissue, derived from the vessels on the walls of the remaining cavity. This is converted into fibrous material, which, after the healing of the external opening, becomes continuous with the superincumbent tissue, and, as it contracts and finally ossifies, causes the depressed cicatrix which is so often seen remaining after this form of bone-disease.

Prognosis.—Inflammation once fully established in a bone rarely terminates by resolution, though such an event is not impossible. The evil effects of the disease may be local in their nature, that is, they may be limited to the destruction of a portion of the bone involved, which subsequently undergoes reparation without materially impairing the usefulness of the part. When the disease implicates a joint, the function of the articulation will most probably be destroyed. When to the morbid action in the bone there is added a deeply-rooted vice of the constitution, rendering the latter acutely sensitive to the presence of the inflammatory products, the danger is greatly enhanced by the hectic symptoms which are likely to follow. The social position of the patient should also exercise due weight in forming a prognosis, as often among the poor and indigent classes an inability to command the proper dietetic and hygienic conditions deprives the surgeon of the most potent means for controlling the disease.

The age at which the disease appears constitutes another important consideration. If in mature or in advanced life, the prospect of recovery is less promising than when the patient is young.

Treatment.—The treatment necessary in osteitis is both local and constitutional.

When the disease can be clearly traced to a traumatic cause, independent of any marked constitutional predisposition,—a condition certainly very unusual.—benefit will be derived from the local abstraction of blood, and elevation of the part when possible, followed by the use of blisters and warm emollient poultices medicated with laudanum. In addition to these local applications, the bowels should be thoroughly acted upon, after which calomel and opium, given in small and repeated doses, will prove to be the most efficient remedies at our command. The mercurial may be administered in doses of half a grain every four hours, with one-fourth of a grain of opium, and cautiously continued, always stopping short of the point of producing ptyalism. If the pain is not urgent, the opium need not be given oftener than once in five or six hours. The diet for the first few days should be restricted, afterwards it may be more liberal. Stimulants are contra-indicated. When the pain continues severe and persistent, the bone should be freely exposed by an incision and one or two openings made into its cancellated tissue by the trephine. In no other way can the pain be so quickly and permanently relieved.

In the great majority of cases, however, the surgeon has to deal with an osteitis the local manifestations of which are only expressions of a general state which, in spite of all his resources, will run a definite course; consequently the treatment must be purely expectant, and local measures are of little value. I am, of course, not here speaking of the disease as it affects joints.

The general health takes precedence of everything else. It will be necessary to direct the use of food rich in all the plastic elements of nutrition, such as milk, eggs, and meat, with fruits in their season, and to cause the patient to live as much as possible in the open air and to migrate during the heat of the summer months to the seaside or the mountains. If the appetite fails, or should emaciation set in, quinine, the iodide of iron, the iodide of potash, and cod-liver oil, with preparations of malt, will be found extremely useful.

When the osteitis terminates in ulceration or caries, it may be recognized, if an external opening is present, by the use of a probe. For this purpose the ordinary silver instrument of the pocket-case (Fig. 856) will usually

Fig. 856.

Silver probe.

answer every purpose, or, should the sinuses be tortuous, a probe made of a piece of light spiral wire may be employed, which, from its flexibility, can be insinuated into the winding track. (Fig. 857.)

Fig. 857.

Author's spiral wire probe.

Frequently, in caries, whether from syphilitic or other causes, the diseased bone will be discharged in minute particles, intermixed with pus, and the case will undergo a spontaneous cure,—a fact which should teach the surgeon the propriety of not being too forward in resorting to early operation.

When, however, nature proves unequal to the task, much may be done towards hastening the cure by removing the diseased osseous tissue. This is notably the case where the caries affects the head of the tibia or the os calcis. The danger of delay in such cases is the involvement of adjoining

portions of the bone by the proliferation of the granulation tissue, so that, within the last few years, I am much more disposed to favor early operations than formerly.

The removal may be effected in either of two ways: by destructive acids, or by the gouge. The acid employed for this purpose by Mr. Pollock is the sulphuric, which is applied, after exposure of the diseased portion of bone, first diluted with an equal quantity of water, and afterwards pure, by means of cotton, or a glass brush.

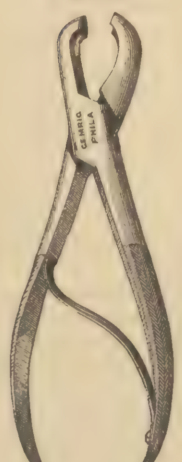
Chassaignac prefers the muriatic acid. The object in view in both applications is a chemical one,—to remove the crumbling bone by the action of the acids upon the lime salts; but it also excites healthy granulations. Fitzpatrick, after destroying the sinuses and exposing the bone by means of the Vienna paste, cut into the osseous tissue with the trephine, and applied the caustic freely to its surface. Boinet strongly advocated the use of the tincture of iodine as an injection, while Notta employed Villatte's liquor,* a preparation much used by farriers. The actual cautery has also been used for the removal of the diseased bone.

I prefer, however, the use of the gouge, as a more speedy and thorough measure for getting rid of the unhealthy structure. The soft parts being divided by a curvilinear or a crucial incision, and the bone exposed, the gouge (Fig. 858) should be applied to the parts, scooping out the rotten and gnawed tissue. For the same purpose a gouge forceps (Fig. 859), or a scraper (Figs. 860 and 861), or a burr-head drill (Fig. 862) will be found use-

FIG. 858.

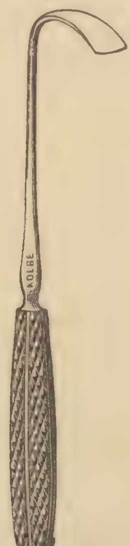
Gouge for removing carious bone.

FIG. 859.



Gouge forceps.

FIG. 860.



Bone-scraper.

FIG. 861.

Bone-scraper.

FIG. 862.

Burr-head drill.

ful. When the healthy structure is reached, it may be determined by its florid appearance and texture, characteristics strikingly in contrast with the gray or dark color and the brittle nature of carious bone. This is the operation of *évidement des os* of Sedillot. After clearing away the disease, the

* Villatte's liquor consists of sulphate of zinc and sulphate of copper, āā gr. xv, liquor of the subacetate of lead, f℥ss, and dilute acetic acid, f℥iiss.

cavity should be lightly packed with oakum or with lint moistened with a mixture of carbolic acid and sweet oil. This may be allowed to remain for two days, after which it must be removed and the parts washed out daily by injections of a solution of permanganate of potash, or a weak solution of Lugol's preparation of iodine, renewing the packing until the opening has granulated to the surface.

When the disease involves the articular ends of the bones, without any disposition to anchylosis, and where the strength of the patient begins to fail under the continued suppuration, excision or amputation will often offer the only means of recovery.

Suppuration.—Another result of osteitis is suppuration. This may be *circumscribed* or *diffused*. Diffused suppuration in long bones is generally central in its commencement, extending gradually towards the periphery: hence it may originate in the medullary membrane. In the short bones this order of procedure is not noticed; it may commence as a periostitis and travel inward. The pus is not found in such cases evenly diffused through the cancelli of the bone, but disseminated in numerous small collections through its substance, at points where the osseous tissue has become softened and its compartments enlarged.

Circumscribed Suppuration, or **Abscess,** first described by Mr. Brodie, may be regarded as an unusual affection. It generally occurs at the articular ends of bones, particularly in the tibia (Fig. 863), and consists in an accumulation of ill-conditioned, offensive pus. The amount of the collection varies very much, ranging from half a drachm to three or four drachms. The spaces of the cancelli become rarefied for some distance around the collection, or the extremity of the bone may become generally expanded. The limiting wall of the abscess consists of a rich plexus of vessels imbedded in lymph and corpuscles.

Fig. 863.

Abscess in the head of the tibia.

Symptoms.—The symptoms indicative of bone abscess are in most respects similar to those of non-suppurative osteitis. The pain is deep-seated, boring, tearing, or gnawing, always very severe at night. The soft tissues over the affected part become very sensitive, swollen, and œdematous, often without any external redness. The strength of the patient begins to fail, and with this there is marked emaciation. The presence of pus is usually attended with rigors, increase of temperature, and profuse perspiration.

Although there are no symptoms strictly pathognomonic of this affection, the presence of a localized enlargement sensitive to firm pressure, recurring attacks of deep-seated pain and rigors, and a temperature above the normal standard, are substantial grounds for presuming the existence of such an abscess, especially when the head of the tibia is the seat of disease.

Treatment.—The treatment of this abscess consists in uncovering the bone by a free incision through the soft parts, and excising, by means of a trephine, a portion of its substance sufficiently deep to expose and evacuate the purulent collection,—a practice introduced largely by Mr. Brodie. As these accumulations are never large, the instrument may not reach exactly the spot where the abscess is situated. On this account the surgeon should not prematurely abandon his search for the abscess. In case of failure it will be proper to extend the limits of the operation beyond the boundaries of the first cut, by employing the gouge. Owing to the neglect of this precaution, Mr. Brodie once amputated a limb which might otherwise have been preserved.

The operation of laying open bone for the evacuation of pus is a very old

procedure. It was advised by Celsus* and by Severinus, also by Heyne† and by Petit. Marchette directed for this purpose an instrument called a "piercer."

In America the operation had been done by Dr. Walker, of Virginia, as early as 1757, and later by Professor N. R. Smith.

Multiple Abscess.—When an abscess follows an acute attack of osteitis, such as may result from cold or local injury, and the track of communication between the surface and the location of the pus is indirect or tortuous, other abscesses may form, very much as is seen in cases of perineal cellulitis. These abscesses may empty into the primary one, or they may establish for themselves an independent opening, perforating the bone at different points. The recurring attacks of inflammation, incident to the presence of these indirect sinuses, are prone to induce hypertrophic changes in the structure of the bone, or to wear the patient out from constitutional irritation.

TREATMENT.—As in the burrowing abscesses of other tissues, so in this, the bone must be freely exposed and its walls cut away with the chisel, so as fully to expose the seat of suppuration and offer a ready escape to all inflammatory products. The wound must be afterwards loosely packed with lint moistened with carbolized oil, in order to secure its granulation from the bottom; and at each renewal of the dressing it will be well to wash out the bone-cavity by injecting a solution of permanganate of potash or of Lugol's preparation of iodine, one-fourth the officinal strength.

Endosteitis and Osteomyelitis.—Diffused suppuration or osteomyelitis is an inflammatory disease, which, commencing in the medullary tissue, afterwards extends to all parts of the bone-structure. In many of its aspects the affection is not unlike hospital gangrene. The disease, though long known to surgeons, has recently been very carefully studied by military surgeons in this country, especially by Dr. Lidell and by Dr. Allen. It occurs in two forms, *acute* and *chronic*.

CAUSES.—Osteomyelitis, though it may arise idiopathically, is in almost all instances the result of traumatic injury, such as contusions, amputations, and gunshot and other fractures. Atmospheric conditions also exert a powerful influence in the development of the disease. During the War of the Rebellion it was observed by Lidell that in overcrowded hospitals, where the hygienic conditions were of an unfavorable character, the fatality from this affection was greatly increased. It was also noticed that patients who had been the subjects of amputation or of gunshot fractures, and were placed in portions of the hospital ward where the air was most vitiated, were much more likely to be attacked by osteomyelitis than those whose beds were more favorably situated.

PATHOLOGY.—The disease may be either partial or general; that is, it may be confined to a very limited portion of the medullary tissue, or it may implicate the entire bone. The different stages of the affection are in most respects similar to those which are witnessed in the progress of unchecked inflammatory disease in other tissues, and are designated by Lidell, *carnification*, *suppuration*, and *mortification*.

The first stage is one of increased fullness of the vessels of the medulla, giving rise to unusual redness in that tissue. This congestion is followed by transudation and infiltration, during which large numbers of cell-forms make their appearance in the meshes of the medullary membrane, which, together with the fibrogenous exudate, impart a marked induration to the structure. The corpuscular bodies, it is thought by Dr. Woodward, are derived by cell-multiplication from the connective-tissue corpuscles of the medullary membrane, and, when the disease reaches the walls of the bone, also from the connective tissue lying around the vessels in the Haversian canals. There are, however, two other sources from which doubtless large numbers of cells are derived, the first source being the blood-vessels themselves, so that a

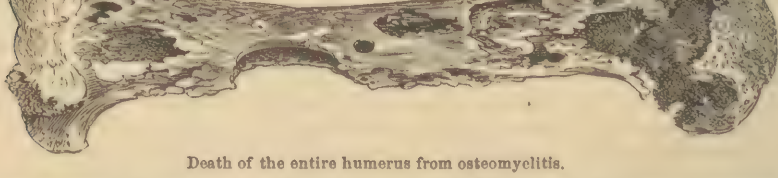
* Lib. viii., cap. 2, 3.

† Lib. de Oss. Morb., p. 68.

certain proportion—perhaps the largest number—of these forms must be credited to emigration; and the second being the cells of the marrow, which under the stimulus of the inflammation are found likewise to increase in number. As the turgescence of the vessels increases, the florid color of the medullary tissue assumes a bluish hue from venous obstruction, and at many points the vessels give way, causing apoplectic extravasation or blood-clots. Under favorable circumstances the disease at this stage may undergo resolution by the absorption of the inflammatory products, or the granulation tissue may be converted into bone, a result which is constantly seen after fractures, and which is also witnessed in the fungoid-looking mass of granulations seen to protrude from the end of a bone after amputations, the callus filling up the medullary cavity and the cancelli at the seat of fracture or at the extremity of the bone.

In the more pronounced varieties of osteomyelitis, so common in military practice, a termination by resolution can scarcely be expected, as the severity of the shock sustained by the components of the bone from the tremendous momentum of the conical ball, and the peculiar hygienic surroundings of the patient, are unfavorable to such a result. The inflammation in these cases passes on to suppuration; the infiltration extends into the cancellated and from thence into the compact or cortical portions of the bone; the Haversian canals become filled with transudation, their walls, by the disappearance of the lime salts, become softened and rarefied, and pus permeates the bone in all directions. While these changes are in progress, the marrow undergoes disorganization, and the fat is forced by the centrifugal current of the inflammatory products through the canals of the bone to its surface. Nor does the morbid action cease here: the periosteum participates in the disturbance and becomes inflamed, followed by the rapid transformation of the subperiosteal transudation into pus, in consequence of which the membrane becomes detached from the bone. After a time the aponeurotic layer of the periosteum may give way, and the purulent matter passing through the perforations become disseminated among the soft parts overlying the bone. Under such structural disorganization, necrosis to a greater or less extent must ensue, involving in some instances the loss of the entire diaphysis of the bone. Occasionally in osteomyelitis the disease extends to the epiphyseal cartilages, when the subjects are persons under twenty years of age, or before these cartilages have become ossified. By disintegration the diaphysis and the epiphysis are disjoined, and they become movable, or even displaced, as in a fracture. If the process just described be still more intensified, mortification or necrosis will follow, preliminary to which the blood-vessels of the medullary and bone tissues become so firmly compressed by the transudation that they are rendered incapable of carrying on the circulation. In this event the medullary tissue becomes very dark in color; the disease, especially when in one of the long bones, travels preferably

FIG. 864.



Death of the entire humerus from osteomyelitis.

in the upward direction; all evidences of cell-vitality disappear; shreds of disorganized connective tissue, discolored by decomposing blood, may be seen here and there in the midst of the diffluent marrow, and from them an offensive odor is emitted,—all betokening mortification or the death of the bone in its entirety. (Fig. 864.)

Symptoms.—Osteomyelitis is not always easy of recognition. When, however, after an injury in which the bone has been damaged, symptoms of deep-seated pain are experienced, attended with great uneasiness in the limb when it is moved, and when there is œdematous swelling accompanied with prolonged suppuration, there is reason to apprehend the existence of the disease. The diagnosis will be still more conclusive if, in addition to the signs already given, there exist separation of the soft parts from the bone, rigors, and fever, accompanied by marked loss of strength. Though periostitis and endosteitis present analogous symptoms, yet there are certain differences which may serve to distinguish these affections from each other.

In endosteitis the pain is more diffused, and will continue for a long time without any external swelling; in periostitis the pain is local, and is accompanied by swelling at the commencement of the disease. In endosteitis firm pressure is necessary to cause pain, while the slightest touch in periostitis will produce suffering. Again, in the latter, knotty and irregular deposits occur on the surface of the affected bone.

Prognosis.—In the aggravated forms of osteomyelitis the danger, not only to the bone, but even to the life of the patient, is imminent. The presence of an unhealthy suppuration diffused through the cancelli of a bone is always attended with risk, and consequently in the severe forms of myelitis many persons die from pyæmia. If the constitutional infection is escaped, there still remains the probable death of the bone. If the disease is limited to the medullary membrane and to the cancellated tissue, the resulting necrosis will be central, the external or compact wall of the bone still retaining its vitality. If the compact tissue suffers in common with the inner wall, the periosteum will participate in the general ruin, and the entire bone will perish. It is not improbable, in instances of such extensive destruction, that the disease will transcend the limits of the diaphysis and invade the intermediate cartilage, the epiphysis of the bone, and the contiguous joint.

Treatment.—Where the signs of osteomyelitis are well pronounced, the bone should be immediately exposed by a free division of the superincumbent soft parts. If, on such exposure, the periosteum is found to have receded from the bone, the surgeon will have determined the presence of a deep-seated suppuration, and may proceed unhesitatingly, if the detachment is not extensive, on the plan practiced by Professor N. R. Smith, to bore one or two openings with a trephine into the cancellated tissue of the bone, in order to furnish a pathway for the escape of the inflammatory products. If, on the contrary, the periosteum is separated from the greater part of the bone, there remains only the alternative of excision or of amputation. When the latter is determined upon, the operation may be done in the continuity of the bone or at the articulation above. If made in the continuity of the limb it will not prove radical, as the disease will continue to invade the remaining part of the bone and will necessitate a second resort to the knife.

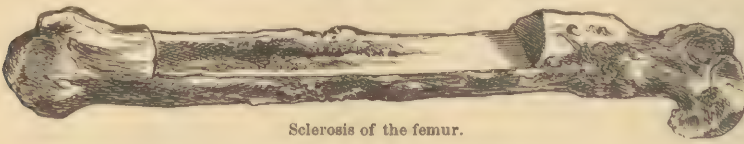
Even in instances where pyæmia has taken place before the surgeon is called to the case, it has been advised to operate, a course which has been successfully practiced by Professor Fayer. Such a procedure, however, should not be accepted unconditionally. Where the evidence of pyæmic infection is conclusive, amputation or excision will only precipitate a fatal result, but in cases where the signs are less decisive, and partake more of the character of septicæmia, the operation may be performed. In the management of these cases constitutional treatment must not be overlooked; not that it can exercise any specific controlling influence over the disease, but because the system demands a vigorous support, and hence the necessity for an ample supply of nutritious food, together with stimulants, tonics, and anodynes. In many instances of osteomyelitis the disease pursues a chronic course, lasting for months or even years, one in which an expectant plan of treatment will be indicated, and where there is no necessity for haste in resorting to an operation. The latter is only required when a sequestrum becomes loosened, in which event it should be removed. If the pain is continuous and severe,

the use of the trephine may be demanded. When, however, the suppuration has involved the principal part of the bone, and the strength of the patient begins to decline, disarticulation, whether of a long or a short bone, becomes imperative, as in the acute form of the disease.

Sclerosis, or Induration.

Another result of osteitis is induration or thickening,—a condition in which the bone appears to consist wholly of compact tissue, the cancellated portion and the medullary canal being occupied by a dense osseous deposit, which, when sawn through, resembles ivory in the closeness of its texture. (Fig. 865.) The disease is not peculiar to any particular portions of the skeleton, though usually the bones affected are the femur and the tibia, and the components of the pelvis, of the cranium, or of the face.

Fig. 865.



Sclerosis of the femur.

The disease generally is not limited to a small portion of the bone attacked, but involves the entire structure, which becomes preternaturally heavy and dense. It is occasionally associated with great periosteal activity, the surface of the bone being covered with nodular deposits. (Fig. 866.) This form answers to the *leontiasis ossium* of Virchow.

Fig. 866.

Sclerosis of the femur, with irregular periosteal deposits.

A temporary form of circumscribed sclerosis is seen in the repair of fractures, in which every portion of the bone at the seat of injury is filled with compact callus. Both conditions are the result of inflammation; but in the latter, after the union is effected, the central portion of the deposition becomes rarefied, as in primary development, while in the former the induration remains permanently.

In sclerosis, the cancelli of the medullary and the Haversian canals being in a great measure filled with new osseous material, the vascularity of the bone is materially diminished.

Causes.—Little is known with regard to the causes which determine sclerosis. It may arise in some instances from constitutional conditions, such as syphilis, but oftener its causes are of a traumatic nature. In one case I was consulted by a gentleman from Tennessee, who, fourteen years previous to my seeing him, had been struck on the head by a spent fragment of a shell, which had produced a scalp wound and an indentation of the external table of the right parietal bone, near the sagittal suture. Three years after the injury he had an epileptic seizure, the attacks of which became every year more aggravated and frequent. I removed two large circles of bone with the trephine, expecting to find either a depression of the internal table or an exostosis, neither of which, however, was present, but instead thereof an extensive thickening with sclerosis of the bone, all of the diploic structure having disappeared.

Surgically, sclerosis possesses little interest, as there are no symptoms which are pathognomonic of its presence. It is barely possible that the growing increase of weight in the limb, when the tibia or the femur is affected, might furnish ground for suspecting the existence of the disease. Even if recognized, we have no remedies with which to combat it.

Necrosis.

The term necrosis is derived from the Greek word νεκρόω, signifying to destroy, and was first employed by M. Louis to express mortification of bone. This writer restricted its application to the death of the entire bone affected. Werdmann used the same term to express the death of small portions of the osseous tissue, but the signification of the word has been extended by modern pathologists until it includes the death of any tissue.

The distinction between necrosis and caries is the same as that between mortification and ulceration in the soft parts,—the same really in kind, but differing in degree,—the first being death of a structure in considerable masses, the second being death by particles. The bones most commonly the subjects of necrosis are the tibia, the femur, the inferior maxillary, the clavicle, the humerus, the ulna, the radius, and the cranial bones.

Although the disease exhibits a marked preference for the long or cylindrical and the short bones, yet the flat ones are not entirely exempt.

Though necrosis generally occurs in the compact tissue of a bone, in consequence of the pressure to which the vessels are subjected in the minute Haversian canals by congestion and transudation, yet it is also found in the cancellated tissue. The reverse is the case in regard to caries, the latter manifesting a peculiar preference for the spongy portions of bone, as in this tissue the space between the blood-vessels and the walls of the cancelli is sufficient to accommodate the inflammatory infiltrate without serious compression of the vascular channels.

The shafts of the bones are much more frequently the seat of the disease than are the epiphyses or their articular extremities.

All parts of a bone are not equally liable to become involved in the destructive process. Necrosis of the femur is commonly met with in the limits of its lower third. When the tibia is attacked, its anterior surface suffers in preference to the posterior one, and the upper end of the bone rather than the lower. When the humerus is affected, the upper extremity is implicated oftener than the lower.

Causes.—The causes are *constitutional* and *local*. While there are some who seem disposed to ignore in a great measure the constitutional origin of necrosis, yet in my judgment it is the *fons et origo* of a very large proportion of all cases of idiopathic mortification of bone. Among children under fifteen years of age, who furnish so many examples of the disease, will be found in almost every instance those unmistakable bodily characteristics which we are wont to term scrofulous: with such an organization, exposure to a cold damp atmosphere, repelled perspiration, insufficient food, an attack of measles or of scarlet fever, a slight traumatic injury, even the violent contraction of the muscles disturbing the superficial fibres of the bone, will be sufficient to kindle into activity those latent conditions which develop the inflammation that precedes the dissolution of the bone.

While the young are particularly the subjects of necrosis, there is also a senile variety of the disease, due to those vascular changes incident to old age which serve to embarrass the circulation through the vessels of the bones.

Constitutional syphilis, especially in its advanced stage, constitutes another prolific cause of necrosis, very commonly affecting the palatine plate of the upper maxillary, the turbinated pieces of the nose, the tibia, the clavicle, the ulna, and the bones of the cranium.

Low forms of fever not unfrequently are followed by necrosis, arising no doubt partly from deterioration in the constitution of the blood, and partly

from a feeble, tardy circulation, favoring congestion in the vessels of the bone, —a condition which is often a fruitful source of inflammation in other tissues. Necrosis of a rib or of the humerus is no uncommon sequence of typhoid fever.

In the same category must be placed those cases of bone-mortification which follow scurvy, smallpox, or disease of the kidneys. Rheumatism must be also enumerated among the causes of the disease, not so much from the retention in the blood of certain products of textural change as from the extension of the inflammation, by continuity, from the fibrous to the periosteal structure, and from the organic changes induced in the bone itself.

The injudicious use of mercury not unfrequently causes the most horrid destructive inflammation of the bones of the maxilla, accompanied by such sloughing of the neighboring soft parts as often, by the vicious cicatrices which follow, to render the unfortunate victim deformed and disabled for life.

Among the local causes of necrosis may be mentioned certain chemical virulents, as phosphorus. Persons exposed to the fumes of phosphorus, as match-makers, are liable to necrosis of the maxillæ. This was first noticed by Heyfelder, of Vienna. The lower jaw is usually attacked, sometimes the upper.

Phosphorus-necrosis will be treated of under the chapter "Diseases of the Mouth."

Among *traumatic* or *local* causes may be mentioned gunshot and other wounds, bruises, concussions, etc. These act either directly by stripping off the periosteum, or indirectly by provoking a suppurative periostitis or by inducing an endosteitis. The extent to which the periosteum can be detached without the death of a corresponding portion of the bone it is difficult to determine. If there is a constitutional vice predisposing to necrosis, the slightest separation will be followed by death: but in a healthy person without any such predetermination, considerable detachments may occur without the utter loss of vitality in the part.

It must not be forgotten that, even though the periosteum be separated, there is another source of blood-supply, namely, the vessels of the medullary membrane.

Divisions.—When the disease is limited to the external part of a bone, it constitutes *peripheral* necrosis, the extent of which varies in different cases, sometimes affecting only one or two lamellæ, at other times extending a considerable depth into the compact tissue. When the necrosis is confined to the interior of the compact substance, or to the cancellated portion, it is termed *central;* when both the compact substance and the spongy tissue are included, it is called *total*.

The following varieties of the disease may occur under the central division.

Multiple Necrosis.—There is a form of necrosis in which several bones of the skeleton are attacked either simultaneously or in succession, which may be named *multiple*. This is not an uncommon condition in tertiary syphilis. I have seen the same wide-spread necrosis follow an attack of rheumatism, and also a convalescence from typhoid fever, where there was no reason whatever for suspecting the existence of a venereal taint. In strumous constitutions multiple necrosis is by no means uncommon, and is generally limited to the outer lamella of the bone. The first form, or peripheral, is likely to follow the detachment of the periosteum, from whatever cause: the second, or central, is caused by damage to the endosteum: and the third, or total, occurs when both the periosteum and the endosteum are damaged.

Non-Suppurating Necrosis.—In this variety the sequestrum lies in a shell of bone covered by a mass of gelatinous granulations and without the presence of pus or external abscesses. It is probable that if the examination could be made early in the progress of the disease, suppuration would be found to exist, the pus in the advanced stage having been absorbed. A parallel case is seen in certain indolent ulcers with redundant œdematous granulations from which only a thin serum is discharged. The diagnosis must necessarily be

very perplexing in such cases, and can only be cleared up by an exploratory opening.

Humid Necrosis has its analogy approximately in the moist gangrene of the soft parts; by Lidell it is termed mephitic gangrene. The disease, beginning in the spongy tissue, ultimately involves the entire thickness of the bone. The necrosed cancelli become soft, presenting a gray or dark-brown appearance, the discharges from which are exceedingly fetid. The destruction is so general and so deeply affects the vitality of the periosteum that any successful attempt to repair the damage need not be expected.

Pathology.—The succession of changes which in the aggregate embrace the dying, the death, and the repair of the necrosed bone, is intensely interesting to the pathologist. These changes include the phenomena of inflammation, the establishment of a line of demarkation, the separation of the dead part, and the provisions made for strengthening the diseased bone.

The inflammatory stage which precedes necrosis may be either acute or chronic. The shafts of the long bones, especially those of the femur, tibia, and humerus, suffer most from acute necrosis. When the articular ends of the cylindrical bones, or the short irregular bones, become the subjects of the disease, the inflammation is usually of a chronic nature.

In whatever way the bone dies, the determining part of the event is the absence of circulation. Assuming the bone attacked to be a cylindrical one, and that from some cause a periostitis is developed, there will follow an inflammatory transudation into the deep layer of the membrane. Not only so, but the contiguous vessels of the compact tissue of the bone participate in the disease, and a like transudation takes place into the Haversian canals. If a careful examination be made at this stage of the disease, the periosteum will be found at some points thickened by the infiltration, while at others suppuration will have been established. The walls of the Haversian canals being unyielding, the effect of this sudden infiltration is to compress the blood-vessels, so as to arrest the circulation in these channels, and thus deprive the bone of the blood necessary for its nutrition, and consequently cause its dissolution. It is thought by some that the destruction of the vessels is brought about by accumulation of the transudation and suppuration between the bone and the periosteum, which by lifting the latter membrane destroys the vascular connection between the two,—a theory which is contradicted by the condition found to exist in the repair of fractures. That the spindle-shaped elevation surrounding the seat of a fracture is not formed by the raising of the periosteum by the callus I have, by numerous experiments, determined to my own satisfaction. But to return to the subject under consideration, the osseous tissue, being deprived of its blood-vessels, dies; it becomes white, gray, or dark colored, is hard, insensible, and bloodless when pierced.

Separation.—The dead bone is now a foreign body, and in order to repair the damage its separation and expulsion from the living bone become necessary. To accomplish this, immediately around the circumference of the dead bone a line of increased vascularization is established, which exhibits the commencement of the process of separation, and forms another illustration of the salutary work of inflammation. A free transudation from the vessels infiltrates the deeper layers of the periosteum and also the Haversian canals; and this, like the induration at the circumference of an abscess, serves to form an embankment which not only prevents the intrusion of morbid matters into the sound bone, but also serves to dissolve the connection between the living and the dead structures.

The effect of this infiltration is to enlarge the Haversian canals and to destroy the union between the inorganic and the organic constituents of the bone. The former become disintegrated, and mingling with the inflammatory products are removed partly through such sinuses as may exist, and partly by the absorbent vessels. The presence of lime salts may be detected

in the discharges by the addition of suitable tests. The animal bases of the bone also become softened. The transudation, consisting of fibrin and leucocytes, is soon penetrated by an outgrowth of capillary vessels, forming a granulation tissue, the suppuration from which forms a groove between the living and the dead structure, constituting the *line of demarkation.* As the suppuration continues, the necrosed part finally becomes wholly disjoined from the sound bone, and either drops out spontaneously or is readily picked away with the forceps. The piece thus detached as a scale, when from the external surface of the bone, including one or several lamellæ, is called an *exfoliation.* All of the changes, therefore, which are concerned in the separation occur in the living bone. The cavity which results from this loss of substance is an ulcer, and is repaired by granulation, or by a process similar to that which takes place in the healing of an ulcer in the soft parts. The resulting cicatrix is depressed, and to it the superincumbent tissues are united.

When the deeper part of the shaft or the entire diaphysis of a long bone dies, the same inflammatory changes occur in the exterior sound portion and in the periosteum contiguous to the dead as have been already described under peripheral necrosis, and by this process the necrosed piece is disjoined from the living. The dead portion thus imprisoned within a sheath or *involucrum* of living bone is called a *sequestrum.*

While these changes are going on, if the new bone is tardily formed, a fracture may be readily produced on the application of a very trifling force.

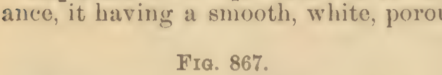
Epiphyseal Necrosis.—When necrosis implicates the shaft of a bone, it will, however extensive, generally not pass beyond the limits of the diaphysis. When the disease is located in the epiphysis or in the articulating extremity of a bone, it is usually followed by the gravest consequences to the joint. The necrosis may affect any part of the epiphysis, central or peripheral, or, indeed, may destroy the entire extremity. Familiar examples of such general destruction are seen in hip-joint disease, in which the head of the femur is often totally destroyed.

Necrosis of Flat Bones.—When a flat bone becomes the subject of necrosis, —a very common occurrence,—the dead piece is always detached as an exfoliation, never invaginated or incarcerated in an involucrum of new bone. The manner of separation is identical in its pathological history with that of the same process in the long bones.

Necrosis of Irregular Bones.—These bones, of which the best examples are those of the tarsus and the carpus, not being laminated, but consisting of a reticulation of cancelli, are most prone to ulceration, but are not exempt from necrosis, in which case the piece is liable to die in its totality.

Sequestra.—A sequestrum is readily recognized by its peculiar appearance, it having a smooth, white, porous or worm-eaten surface, with ragged dentated or spiculated edges. When such a fragment has been exposed for some time to the air, the color often changes to a dark gray or brown. Sequestra differ much in size, in some instances consisting of a small fragment, in others comprehending the entire diaphysis of the bone. In form they are sometimes flat, sometimes concave, and at other times completely cylindrical. (Figs. 867 and 868.)

FIG. 867.



Cylindrical sequestrum from the femur, following amputation.—Smith.

The structure of a sequestrum is very hard, but brittle, and in chemical constitution it differs from normal bone in having a very large preponderance of earthy over animal matter. This disproportion between the inorganic and the organic components is not the same in all sequestra. When the necrosis

follows an acute course, and the dead piece is quickly detached, this disproportion is very much lessened.

Fig. 868.

9⅞ inches

Cylindrical sequestrum from femur.—American Medical Museum.

There are two peculiarities possessed by a sequestrum which are worthy of notice, namely, its cribriform appearance and the irregular spines which project from its margin or extremity. These topographical features are not due, as was at one time supposed, to erosion from contact with the pus in which the dead bone is bathed. Any influence of this kind, if it operates at all, must be very insignificant. We must seek for the true explanation in the irregular proliferation of the granulation tissue which separates the dead from the living bone. The same condition may be noticed in the irregular indentations which are left in the soft parts after the separation of a slough. It is this intercalation between the living and the dead osseous tissue, together with the penetration of the granulations into the foramina of the sequestrum, which often so obstinately resists the traction efforts made by the surgeon to remove the necrosed part.

The manner in which the spontaneous extrusion of a sequestrum can take place has also formed the subject of much speculation. I have seen a considerable portion of the shaft of the femur protruding to the extent of three inches externally, which had become almost black from its long exposure to the air. In time, I doubt not, the entire piece would have escaped without any assistance from the surgeon. Hippocrates thought that the sequestrum was pushed forward by a fleshy membrane (granulations) which grew underneath; Swieten referred the movement to the pulsation of the arteries; while others, and among them Bell, attributed the change of position to the pus and the growing granulations. If to the latter we add the jars to which the limb is exposed, we have doubtless the most rational explanation of the process. In one instance of spontaneous extrusion of a sequestrum the popliteal artery was pierced, and a fatal hemorrhage followed.

In rare instances a sequestrum may become encased or encysted within a wall of new or living bone, and remain quiescent for a long time. Broca mentions two cases of this kind, in one of which the necrosed piece was incarcerated for fifty-three years.

Provisions for repair.—When a considerable part of a cylindrical bone, or the entire bone, becomes the subject of necrosis as a result of periostitis or osteomyelitis, the osteogenetic function of the periosteum, and, when the death is not total, that of the external lamellæ of the bone, and perhaps, in some cases, the endosteum, become exceedingly active. A new deposition of osseous matter or callus takes place on the outer surface, until the shaft may acquire an extraordinary thickness, the remains of the old shaft lying in the centre as a sequestrum. (Fig. 869.) The new bone thus formed is often granular (Fig. 870), or rough and nodulated. (Fig. 871.) The activity of the periosteum in the work of providing a new bone, or strengthening the walls of one partially destroyed, cannot now be doubted. In this way the entire shaft of a long bone may be restored. The vacuum remaining after the removal of a central sequestrum is filled up by granulation tissue, which subsequently ossifies, the activity of the periosteum is at once sensibly diminished, irregularities over the surface of the bone are rounded away, and in time the medullary canal is probably measurably reformed. When the epiphysis is attacked with necrosis, as occasionally occurs in young scrofulous subjects, this power of restoration is lost.

In order to provide for the discharge of the pus, and also to offer a way

of escape for the dead parts, another remarkable provision is the formation, at points where the periosteum is deficient, of openings through the outer wall

Fig. 869.

Sequestrum formed by the entire diaphysis of the tibia surrounded by new bone.—From a specimen in the museum of the University of Pennsylvania.

Fig. 870.

Extra-granular deposition of bone in necrosis of the humerus.—American Medical Museum. x Spec 2749

Fig. 871.

Nodulated deposition of callus in necrosis of the shaft of the tibia.—From a specimen in the museum of the University of Pennsylvania.

Fig. 872.

Necrosis of the tibia with cloacæ.—Smith.

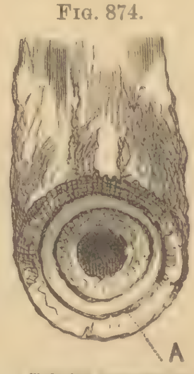
of the bone, called *cloacæ*. (Figs. 872 and 873.) These are not always present, in which case the products of inflammation can only be removed by absorption.

Fig. 873.

Necrosis of the tibia, with a sequestrum protruding through a cloaca.—Smith.

A very curious tubular sequestrum sometimes follows amputation, the dead bone being situated between two tubes of living bone. (Fig. 874.) I have removed these peculiar cylinders when they have extended several inches up the shaft of the bone. I think that they are most frequently met with after amputation for gunshot injuries of the bone. Occasionally the end of the bone possessing such a sequestrum is large and bulbous, the granulations from the medullary membrane having spread over the extremity and become ossified. The rationale of the formation of these sequestra is somewhat obscure. The portion of bone which dies is the inner layer,—the part more especially nourished by the endosteum. It would seem probable that any cause which would destroy the inner lamellæ would destroy the medullary membrane also, in which case no inner cylinder of new bone could be constructed. Markoe thinks that these sequestra depend upon some injury to the nutritious artery, inasmuch as this vessel is destined for the supply of the medullary tissue. Such an accident would temporarily

Fig. 874.



Tubular sequestrum (A) of the femur after amputation.

interrupt the flow of blood to that structure, during which time the inner lamellæ would perish before the circulation could be sufficiently established through the branches of the periosteum. This explanation, in my judgment, is the most satisfactory one which has been given. The necrosis often progresses so quietly and produces so little local disturbance that it may exist for a considerable time without being suspected.

Ring Sequestra.—Another kind of sequestrum is the ring: this is frequently seen at the end of a bone after amputation.

Symptoms.—The symptoms indicative of necrosis are such as belong to inflammation. There is local tenderness, followed by deep-seated throbbing or gnawing pains, which are characterized by marked evening exacerbations; the skin may remain for a long time unaffected, though frequently it becomes œdematous, glossy, and of a dark-red color. These phenomena may continue for a short time and then subside, leaving only a somewhat supersensitive condition of the limb when it is jarred, or when some unusual exercise has been taken or the feet have been exposed to cold and dampness. This period of quiet is liable at any moment to be interrupted by a recurrence of the inflammatory symptoms. The pain again increases, the skin becomes inflamed and swollen, the nights are passed in restlessness, and not unfrequently the patient suffers from slight fever. These are the ordinary signs of osteitis, and while they are not invariably followed by necrosis, they nevertheless point very strongly in that direction, especially if the bone is a cylindrical one. If, however, after a preliminary period of such suffering, induration and thickening of the parts take place and abscesses form in the superincumbent soft parts, ending in sinuses which refuse to heal, and through which unhealthy granulations crop out having an umbilicated or a papillary form, all obscurity is removed, particularly if, on passing a probe along one of these fistulous tracks, the instrument comes in contact with denuded bone.

In central necrosis, when ulcerated openings or cloacæ exist, the probe can be conducted through the peripheral portion of the shaft and be brought directly against the interior sequestrum. The pus first discharged may be healthy in appearance, being the result of an extension of the inflammation to the soft tissues, and therefore partaking of the nature of an ordinary abscess, but subsequently the discharges become sanious and watery, and emit an offensive odor, indicating that they originate in the bone and find their way out through the cloacæ and sinuses to the surface. The inflammation which extends to the soft parts covering a necrosed bone soon glues together the different planes of tissues, inducing both atrophy and fatty metamorphosis of the muscles. When the suppuration is free, or even when only moderate and prolonged, the general health begins to fail. There is a marked loss of strength and flesh, the appetite fails, the face loses its color and wears an anxious expression, and often towards the close of the day the palms of the hands and the soles of the feet become hot, followed by a marked acceleration of the pulse.

Prognosis.—Any opinion as to the future termination of a case of necrosis, to be valuable, must be based on a variety of considerations. If the patient is young and possesses a good constitution, if the disease is confined to a single bone, is not too extensive, and is not too deeply situated, a favorable result may be reasonably anticipated. The particular bone involved must not be overlooked. Necrosis of the femur is much more serious than the same disease in the tibia, and necrosis of the bones of the cranium or of the pelvis is more dangerous than either.

When the articulating extremity of a bone is attacked, the risk to life and to limb is much increased. Adults and aged persons are less likely to recover from the effects of necrosis than the young. Indeed, every case of necrosis is environed with so many possibilities of evil, that the surgeon cannot feel otherwise than anxious about the issue.

Evil Effects.—The dangers which threaten a patient affected with this disease are multiform. If in the bones of the skull, meningitis or intra-cranial abscess is liable to occur. If in the head of the femur, the disease may involve the ilium and extend into the pelvis, causing destructive abscesses in the latter cavity. A dead fragment of bone may lie in or may penetrate an epiphysis, and, entering the cavity of a joint, be followed by anchylosis or by the loss of the limb. A sequestrum, in its extension by natural processes, is liable to come in contact with a great blood-vessel, and, by exciting ulceration in its coats, give rise to fatal hemorrhage. This has happened in a number of instances. To these may be added those structural waxy and fatty changes which are provoked in internal organs, especially the kidneys, by long-continued suppuration, and the liability to pyæmia, erysipelas, and, if constitutionally disposed, to tuberculosis of the lungs.

Treatment.—There are two general objects to be had in view in the treatment of a case of necrosis, namely, to moderate the intensity of the preliminary osteitis and of the pain, and to remove the sequestrum.

The first is accomplished by elevating the limb, by local depletion and the use either of anodyne lotions or warm poultices, as may best comport with the sensation of the patient, and by the exhibition of opiates to relieve pain; a blister applied directly over the diseased part is often followed by the greatest benefit. When the disease has a syphilitic or a rheumatic origin, great benefit will be derived from the use of full doses of the iodide of potash, and in strumous cases from the administration of cod-liver oil and the iodide of iron. A mixture consisting of three parts of the tincture of iodine and one part of laudanum, freely applied over the diseased part twice a day, will be found to produce a good effect. The bowels must be regulated, and the diet consist of nutritious but unirritating articles of food. Whenever fluctuation is discovered, or even before, when there are sufficient reasons for believing in the presence of deep-seated pus, whether under an aponeurosis or beneath the periosteum, an opening should be made for its escape. The suffering from these confined collections is often intense, and in delicate or irritable constitutions even dangerous. When the inflammation is limited to the external lamellæ of the bone, by making an early opening we not only alleviate the violent pain, but also limit the spread of the disease. These incisions should be made, when carried through the periosteum, in the longitudinal axis of the bone, in order to furnish a free escape for the pus.

Removal of the Sequestrum.—As long as the dead bone remains, the suppuration and the sinuses will continue. Its removal, therefore, becomes a matter of great importance, and yet, save in one or two exceptional cases, there can be no justification for interference, with a view to its extraction, until nature has effected its separation from the living bone. If there is any one practice whose propriety is more strongly established than that of any other in bone surgery, it is the abstinence from all cutting operations antecedent to this separation. The surgeon may have to wait many months, perhaps years: but time does not alter the law. How to determine the time for interference is not a difficult task. A probe, or, what is better, a director, should be carried through one of the sinuses in the bone until the sequestrum is reached, when by firmly pressing upon the piece its mobility can be ascertained, or by tapping it with the instrument the hollow sound which indicates its detachment may be heard.

Sequestrotomy.—If the sequestrum on the application of these tests is found to be loose, its extraction cannot be too soon accomplished. When free bleeding is anticipated, a tourniquet may be placed upon the limb above, or Esmarch's elastic roller may be applied. The incisions through the soft parts must be planned so as to avoid injuring important vessels and nerves or dividing muscles, and should be ample, in order that the bone may be properly exposed. In many cases it will be useful to insert a director through one of the sinuses leading most directly into the bone, as a guide for the knife.

Having reached the bone, the next step in cases of central necrosis is to

cut away the involucrum or new wall of bone in which the sequestrum is encased. This is readily done by the chisel and hammer (Figs. 875, 876, 877, 878), or, when two or more cloacæ are favorably situated, by dividing the intervening bridges of bone with strong cutting pliers (Figs. 879, 880) and opening them into one another, when the sequestrum being exposed can be seized with a pair of strong bone forceps (Figs. 881, 882, 883) and withdrawn.

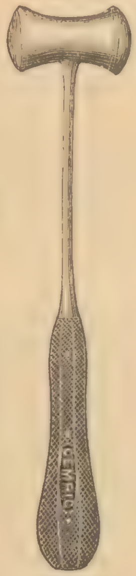
FIG. 875.

FIG. 876.

FIG. 877.

Different forms of bone chisels.

FIG. 878.



Hammer.

FIG. 879.

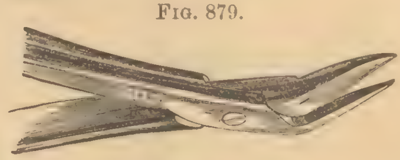
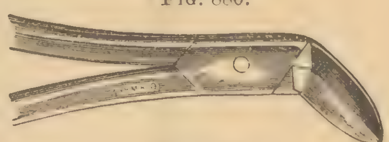


FIG. 880.



Bone pliers.

Sometimes the sequestrum is wedged in between the irregularities of the living bone, or is pinned by osseous spines running into the orifices or depressions upon its surface, in which event an advantage may be gained by slipping a lever or elevator (Fig. 884) under one of its edges, and prying it out of the bed in which it is locked.

When the opening in the involucrum is too small for the extraction of the dead bone, the latter may be cut in twain by the pliers, and each half removed separately.

Dr. Garretson, of this city, has introduced into the practice of surgery a dental engine, which is not only admirably suited for many operations on the bones, but the applications of which are almost unlimited.

The engine resembles an ordinary pedal lathe, having a fly-wheel, a driving-pulley, and a cord extending between the two in order to communicate a revolving velocity to a movable arm, which consists of a flexible shaft of wire, inclosed in a pliable sheath, on the free end of which is a mandrel for the reception of the instruments to be used. (Fig. 885.) Into the flexible arm can be fitted drills (Fig. 886) of different sizes, a trephine (Fig. 887), a circular saw (Fig.

FIG. 881.

FIG. 882.

FIG. 883.

Different forms of bone forceps.

FIG. 884.

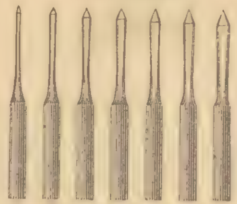
Lever.

888), a circular knife (Fig. 889), and burrs for reaming out the cavity of a bone (Fig. 890).

FIG. 885.

White's surgical engine.

FIG. 886.

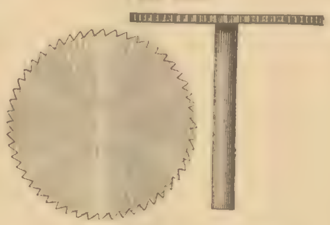


Drills of different sizes.

FIG. 887.

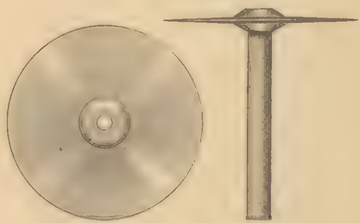
Trephine.

FIG. 888.



Two views of the circular saw.

FIG. 889.



Two views of the circular knife.

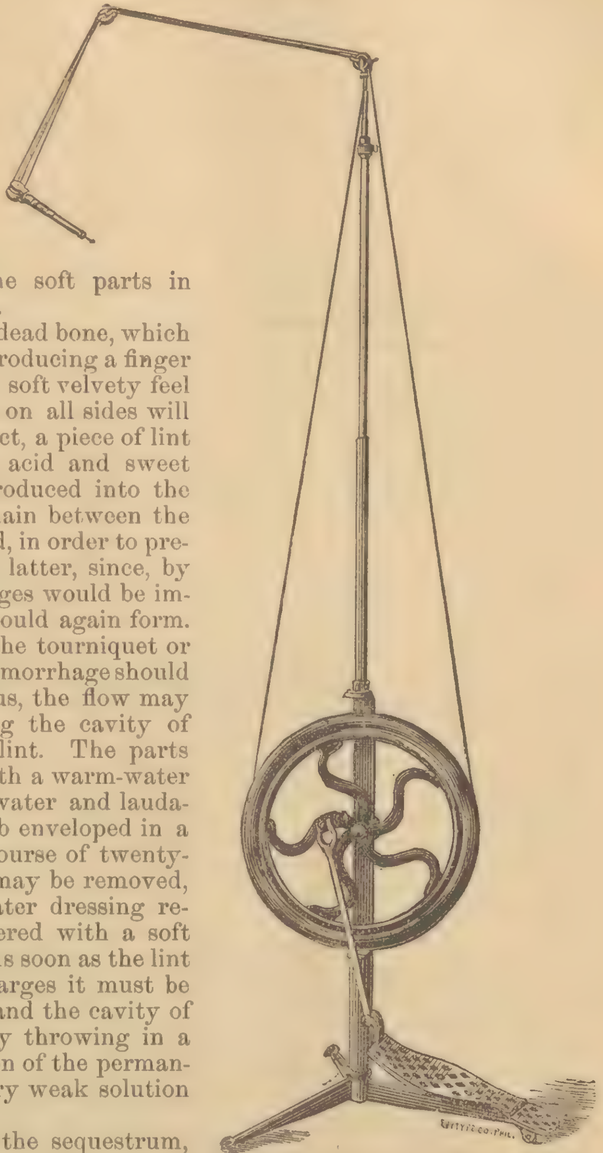
FIG. 890.

One form of the burr drill.

There are three forms of the surgical engine. Two of these are by S. S. White, one of which can be attached to a table and worked by the hand of an assistant, and the other rests on the floor and is driven by the foot. (Fig. 885.) The arm in both is a continuous piece, is flexible, and can be worked in every possible direction. The third engine is one constructed by Dr. Bonwill, and is represented in Fig. 891. The arm is made up of two solid rods of metal, and the power is transmitted direct to the tool or instrument. All of these engines are capable of doing what is claimed for them by their makers, but which of the three can justly lay claim to superiority I do not undertake to decide. There are other modifications of the engine, but the three just

mentioned appear to be the most valuable. The rapid revolving power of these engines, numbering from fifteen hundred to five thousand revolutions per minute, and their capacity to carry a drill the size of a cambric needle, or a knife or saw ten and a half inches in diameter, enable the surgeon to divide tissues with comparatively little pain. Dr. Albert H. Smith, of this city, has used the engine with the greatest satisfaction for denuding the soft parts in operations on the vagina.

Fig. 891.



Bonwill's surgical engine.

After removing all the dead bone, which can be determined by introducing a finger into the cavity, when the soft velvety feel of the granulation tissue on all sides will sufficiently declare the fact, a piece of lint moistened with carbolic acid and sweet oil should be gently introduced into the bone, and allowed to remain between the lips of the external wound, in order to prevent quick union of the latter, since, by such healing, the discharges would be imprisoned and abscesses would again form. If after the removal of the tourniquet or Esmarch's bandage the hemorrhage should be profuse and continuous, the flow may be controlled by packing the cavity of the bone with strips of lint. The parts are now to be covered with a warm-water dressing, or one of lead-water and laudanum, and the entire limb enveloped in a roller bandage. In the course of twenty-four hours the bandage may be removed, and either the warm-water dressing renewed or the parts covered with a soft flaxseed-meal poultice. As soon as the lint is loosened by the discharges it must be removed from the bone, and the cavity of the latter washed out by throwing in a gentle stream of a solution of the permanganate of potash or a very weak solution of iodine.

After the removal of the sequestrum, the involucrum soon begins to contract, the interior granulations undergo ossification, and at length the cavity is filled by callus, until, as in the case of repair after fracture, the bone becomes a mass of compact tissue. This new bone subsequently is measurably absorbed, and an attempt is made to reform the medullary canal. How perfectly this is done we do not yet fully know. The wound in the soft parts also heals by granulation, and the cure may be considered complete.

When necrosis affects the bones of the cranium, there is often a persistent indisposition in the disease to become limited or to establish a line of demarkation. It continues assiduously to invade the contiguous portions of

the osseous tissue. If, after waiting for a reasonable length of time, the necrosed piece does not begin to loosen, it will be better to expose the bone, and by a careful use of the engine and a fine saw, or by the chisel, to cut away the piece beyond the limits of the diseased structure. The danger of long-continued delay is the probability of intra-cranial abscess, or of meningitis.

Should a vessel be wounded by the sequestrum in the natural efforts for its expulsion, the parts must be laid open freely and the vessel searched for and tied; in the event of the principal artery being torn, amputation will offer the best prospect of recovery.

Rachitis.

Rickets, from the Greek word *ῥαχις*, signifying a spine or a ridge, is the name very improperly given to a peculiar disturbance in the nutrition of the bones, which consists in an abnormal increase of the cartilaginous and transition substance of the osseous tissue, the lime salts at the same time being deficient in quantity. This affection belongs to childhood, and was at one time called the *English disease*. Though allusions have been made to this morbid change of the bones by Hippocrates, Galen, Celsus, and other ancient writers, yet it is to the English that the profession is chiefly indebted for a more exact knowledge of the disease. Until the time of Levacher,* rickets and mollities ossium were regarded as the same affection. The distinction between the two has been very lucidly established by the labors of Virchow.

The disease is frequently met with in Great Britain and on the Continent, rarely in the United States. In London, according to Jenner, it is very common among the children of the poor. At the Hospital for Sick Children in that city, 2.36 per cent. of the inmates exhibited signs of rickets,† while among those under two years of age it prevailed to the extent of 30.3 per cent. Ritche, in his clinical observations on this disease among the children of Manchester, gives the same percentage,—that is, 219 rickety out of 728 out-patients. This varies very little from the statistics of the general clinic at Prague,‡ which furnish 504 cases of the disease among 1623 children under five years of age. The same author states that in Berlin, of 4715 patients under five years of age observed, 650 suffered from rickets, or about 13.8 per cent. At the Almshouse, Philadelphia, according to Dr. John S. Parry,§ 25 per cent. of all the inmates of the children's department exhibited signs of this disease, which is about the same proportion as that given by Knettner for all the children of Dresden. I am satisfied, from observations which have been recently made, that the estimate of Dr. Parry was entirely too high. Dr. Hunter, who has examined carefully the same field, found 6 cases of rickets among 99 white, and 6 cases among 36 colored children, or only 12 cases of the disease in a total of 135 children,—8.08 per cent.

Rickets may occur during fœtal existence, or at any period between birth and the fifth year of life. It is seldom seen as late as puberty. The largest number of cases are met with between the first and second years of infancy. Of 346 cases of the disease examined by Guérin, 98 occurred during the first and 176 during the second year. Only 5 cases were noted after the sixth year. Among the whole number, 3 were examples of fœtal rickets. The statistics of Ritche, comprising 219 cases, furnish 65 instances of the affection during the last six months of the first year, and 109 between the first and the second year. From the fourth to the fifth year only 4 cases were observed, and none at a later period. Von Rittershain, in 521 children affected by the disease, found that 329 of them were between six and twenty-four months old.

* Traité du Rachitis, 1772.
† Gee on Rickets.
‡ Solomon, in Ziemssen's Cyclopædia, vol. xvi. p. 71.
§ American Journal of the Medical Sciences, January and April, 1872.

Sex.—On this point there is some discrepancy between different statisticians. The aggregate summary of the observations made by Guérin, Bruenniche, Ritche, and Von Rittershain would make the sexes nearly alike in their liability to this affection,—that is, there were 436 males against 484 females in 920 cases of the disease.

In striking contrast with this comparison are the results obtained by Dufour and Mayolin, in which, according to the first-named writer, the number of girls suffering from rickets was found to be fifteen times as great, and according to the second, twenty times as great, as that of boys similarly affected.

Causes.—The causes which operate to produce rickets are not certainly known. They are probably, in most instances, of a general character, as may be inferred from the early appearance of the disease, and from the number of bones which are simultaneously affected. The influence of hereditary conditions transmitted, especially on the maternal side, has been invoked by authors in explanation of this affection, especially tuberculosis and syphilis. The multiform constitutional defects which are transmitted from parents laboring under tubercular disease render it probable that, occasionally, such a dyscrasia may be influential, by vitiating the nutrition of the fœtus, in developing the disease; but examples of this kind are so rare that they must be deemed exceptional: and as to a syphilitic rachitis, I have never seen anything which would in the least tend to corroborate the existence of such an affection of the osseous tissue, though it is stated by Wagner and others that such appearances are sometimes present.

From some observations which I have made, but which as yet are too crude to admit of a formal presentation, I am disposed to think that ultimately the predetermining vice will be found to originate in the cells of the medulla.

Food.—Whatever may be the predisposing or underlying conditions of rachitis, there can be no doubt that a powerfully determining influence is to be found in the combined operations of imperfect food and of damp, badly-lighted, and imperfectly-ventilated dwellings. On this point there is little difference of opinion among writers.

In what this imperfection of food consists has not been definitely determined. It cannot be from the early weaning of infants, or from the use of artificial articles of nourishment, as it is well known that the children of many German mothers, who nurse at the breast for a long time, supply at least as many examples of rickets as are found among those fed in a different way, and, according to Billroth, the disease occurs with about equal frequency in all classes of society.

The experiments which have been made on lower animals, by confining them to an exclusive kind of food, or to a diet in which the lime salts were largely absent, have yielded only negative results. As the essence of rachitis consists in an inordinate excitation of the normal or bone-forming process, the influence of any agents capable of unduly stimulating osteoplastic activity would conduce to the morbid condition under consideration.

If the experiments of Wagner and Heitzmann prove to be reliable, we have in phosphorus and in lactic acid irritants which cause an extraordinary proliferation of cartilage-cells and of transition substance, and if to this be added a deficiency of salts concerned in calcification, we have apparently the conditions requisite for the disease. The power of lactic acid to attack the inorganic constituents of bone is unquestionably great, and its abundant presence in the intestinal canal of children suffering from disturbed digestion is equally clear, but its alleged power of osteoplastic stimulation is against many analogies.

Pathology.—The changes which take place in the skeleton of rachitic subjects affect the long, the flat, and the irregular bones. These become enlarged, thickened, softened, and deformed by curvatures. This enlargement is partially noticeable at the epiphyses, which, by their increased size

and the lateral bulging of the soft redundant cartilages between the diaphyses and the epiphyses, caused by muscular contraction, give rise to the term articuli duplicati, or double-jointed.

In the early stage of the disease all parts of the bone—periosteal, medullary, cortical, and cancellated—are found to be greatly congested, deeply reddened, and filled with a gelatinous transudation. The changes are more distinctly noticed at the epiphyses than in the diaphyses. Instead of the regular stages and distinct boundaries observed in the normal development of bone, there is a singular disorderly commingling of the exaggerated cartilage proliferation and transition substance, with calcification. The cartilage-cells, stimulated to excessive multiplication, are transformed, some into bone-corpuscles, some into medullary cells, and others into connective-tissue forms.

The same process is in active operation in the deep periosteal layers, the material accumulating to such a degree as to add much to the thickness of the shaft. The effect of these changes is to soften and separate the cortical lamellæ and enlarge the spaces of the cancelli until the bone becomes so soft, spongy, and pumice-like that it may be bent, indented, or misshapen in various ways by pressure, or by muscular contraction. Rokitansky has also shown that the product resulting from boiling rickety bones is unlike the chondrin or other animal matter of sound osseous tissue.

With these alterations there are simultaneous ones affecting the inorganic components of the bone. In the normal long bones of children, the earthy constituents make from 63 to 67 per cent. of the total bulk, and the animal or organic from 33 to 37 per cent.

In an analysis of a rickety scapula and humerus, given by Rokitansky, from Ragsky, the inorganic constituents amounted to only 18.88, and the organic to 81.12, a loss in the first, and in the other a gain. In a mean of seven analyses made by Friedleben of rickety ribs, the inorganic constituents amounted to 37.19 and the organic to 62.91.

In addition to the morbid changes in the bones, the internal and other organs undergo important structural alterations. The spleen becomes hypertrophied; the lungs are attacked by catarrhal, pneumonic, or tubercular disease; the bronchial and the mesenteric glands are enlarged; the intestinal glands are involved, and, as a result of disordered nutrition and the consequent emaciation, the muscles waste and lose their color; the liver becomes somewhat enlarged and fatty; and, in some instances, the ventricles of the brain are found filled with serum, and the brain itself œdematous.

Symptoms.—The commencement of rickets is usually so devoid of all prominent or distinctive symptoms that the true nature of the malady may remain for some time unobserved. Ordinarily, however, the complaint is inaugurated by some disturbance of the digestive organs, indicated by flatulent distention of the intestines, and by a tumid abdomen, diarrhœa, sour eructations, and unnatural perspirations. To this last-named symptom, occurring at night and about the head, Jenner* attached considerable importance, as being diagnostic of the disease. The child becomes dull and spiritless, ceases its accustomed plays, is indisposed to all movement, sleeps fitfully, complains when the limbs are pressed, and at length sits with the spine bent and with the head sunk down between the shoulders. This position, together with the disproportion existing between the size of the head and that of the face, gives to the former an unreal magnitude, and confers an expression of thoughtfulness and maturity to the latter altogether foreign to the age of childhood. With the intestinal disturbances the dentition is retarded or arrested, or, if the teeth have already passed through the gums, they often begin to decay and loosen; the bones swell, especially the epiphyseal extremities of the long bones, at the wrist, elbow, and knee, which, from their exposed positions, become markedly prominent. The structural changes having advanced sufficiently far to diminish the natural resistance of the bones, the

* St. Bartholomew's Hospital Reports, 1868.

latter undergo various distortions, as the result of the weight of the body or of muscular action. The lower extremities curve outward, and, if the child is old enough to walk, the gait is waddling and unsteady; the upper extremities become bent forward; the sides of the chest, pressed by the scapular and humeral muscles, are flattened, and, in consequence of the soft, unresisting nature of the cartilages at the anterior extremities of the ribs, the sternum is forced forward, giving an unnatural prominence to the breast (*pectus gallinaceum*, or chicken-breasted), the rationale of which has been particularly described by Shaw.* This deformed condition of the thorax, by which the pulmonary chambers are encroached upon, the lungs displaced, and the nerves subjected to irritation, as in Pott's disease of the spine, has much to do with inducing lung complications.

FIG. 892.

Rachitic skeleton in the museum of the University of Pennsylvania.

Deformities of the pelvis may likewise ensue, and will vary in their character according to the manner in which the pressure is applied to the bones, whether by sitting or by creeping. If in the former way, the mobility of the sacro-iliac junction will allow the sacrum to be forced forward, thereby diminishing the antero-posterior diameter of the pelvis; and if in the latter way, by a general sinking of the entire sacrum towards the anterior boundaries of the pelvis, and an undue projection of the posterior borders of the innominate bones. (Fig. 892.) These deformities in the female may seriously affect the mechanism of labor in after-years.

The deformities which occur in the course of the spinal column, depending on the rachitic changes in the intervertebral and epiphyseal cartilages, as well as in the bodies of the vertebræ, are generally expressed by magnifying the natural antero-posterior curvatures. Lateral and rotary curvatures are occasionally witnessed, and are to some extent caused by the child's habit of twisting the body in order to see objects to one side or behind. Green-stick fractures of the long bones are often produced as a result of the disease.

In the cranium, the fontanelles remain open, and the sutures continue unclosed, which, with the continued enlargement of the anterior and posterior

* On Distortions of the Spine and Chest, 1823.

portions of the head, gives to the skull a fictitious magnitude. Another very remarkable change is noticed in the occipital bone, to which the name of *craniotabes* has been given. The bone at certain points diminishes in thickness until finally it may at these localities entirely disappear, leaving only the pericranium and the membranes of the brain as a covering to the latter. This condition Dr. Jacobi refers to the combined effects of the weight of the child's head upon the pillow and that of the brain within acting on the softened tissue of the bone and gradually causing its removal.

There is in rachitis an arrest in the development of the entire skeleton, which, as has been shown by Humphrey,* is most apparent in the bones of the lower limbs, particularly the femurs.

To the symptoms already detailed may be added the occasional presence of laryngeal spasm.

There is a mild form of rickets in which neither the constitution at large nor the bones are extensively involved. The disease consists mainly in the want of general vigor. The child, though slow in walking, is rarely unable to stand upon his feet; the bones of the leg are bowed externally, and the gait is waddling. The epiphyses of the bones at the knees, wrists, and elbows are not enlarged, though the front of the chest may be prominent,—"*chicken-breasted*." The disease is rarely fatal, and is frequently met with among the poorer classes of a city population. Negro children appear to suffer most. The curves in the bones often remain permanent through life. (Fig. 893.)

FIG. 893.

Curved tibia and fibula. From a specimen in the College of Physicians, Philadelphia.

PROGNOSIS.—When the disease, commencing about the second year or later, is confined to two or three bones, and when the nutrition is not too profoundly disturbed and the case tends to pursue a chronic course, the prognosis, as regards the life of the child, is not altogether unfavorable though few recover altogether from the deformities entailed by the disease. The practitioner must not be deceived by those remissions which not unfrequently take place in the course of rachitis, and during which intervals the general health of the child rallies for a time. These are usually deceptive calms, which will be followed by a return of the former symptoms, and not unfrequently in an intensified degree. When an auspicious change does set in and convalescence becomes assured, the gastro-intestinal symptoms subside, the abdomen becomes soft and less distended, the dentition advances in a natural manner, the emaciation is arrested, the swollen epiphyses diminish, the bones grow abnormally solid and heavy by a large deposition of the lime salts, and finally, after a lapse of years, the patient is restored to health.

In the majority of instances, unfortunately, the disease does not run so favorable a course: the little sufferer continues to emaciate; the discharges from the bowels become more thin, watery, and offensive; the tympanitis increases; fever is constant; the urine becomes scanty, and the patient perishes either from sheer exhaustion, or from bronchial or intestinal catarrh, or sometimes the fatal termination is hastened by the occurrence of some of the exanthemata.

The *diagnosis* of rachitis is not difficult when once that disease is established. The affection with which it has been confounded is osteomalacia. The points of distinction will be noticed under the last-named disease.

TREATMENT.—In the management of a case of rickets, attention should be given, first, to the hygienic conditions by which the patient is surrounded. The importance of securing a situation free from dampness, with abundance of fresh air and sunlight, is so apparent as to require no arguments for its

* Medico-Chirurgical Transactions, 1862.

enforcement. The character and the quality of the food are next to be carefully examined. Of course, if the child is under one year of age, there can be no nourishment so well adapted for its use as the maternal milk; but if the mother is feeble and out of health, if she labors under any constitutional vice,—tubercular, strumous, or syphilitic,—or if the supply of milk is insufficient to meet the demands of the infant, a healthy wet-nurse should be provided, or, if this is out of the question, the child must be supported on properly diluted cow's milk. Different kinds of artificial nourishment can be employed, such as condensed milk, and other forms of infant food.

When the child is ten or twelve months old and the mother's supply of milk is not abundant, the deficiency may be supplemented by a little animal broth. In children still more advanced in years, and in whom the teeth are present, considerable license may be allowed in the variety of the aliment: fresh beef grated into a pulp, salt ham, farina, a little potato, and fruits, such as strawberries, blackberries, and ripe peaches, may often be used with decided advantage.

The medicinal agents must be administered with a view to meet special indications. Among the most prominent of these is the disordered state of the digestive organs, to meet which, and possibly to supply the calcareous defect, lime may be given in some form most readily accepted by the system. Lime-water, exhibited in the milk or alone, answers every purpose. To aid the stomach in the preparation of the food for absorption, pepsin will be found useful, and, when not rejected, cod-liver oil is capable of accomplishing much good by its alterative and nutrient properties, thus checking the rapid waste of the adipose tissue. To restrain the bowels, and to maintain the structure of the blood, the tincture of the chloride of iron, or, if a more astringent preparation be demanded, the liquor ferri pernitratis, may be given; for the same object, minute doses of Dover's powder may become necessary. Other tonics, such as quinia, cinchona, gentian, and quassia, are occasionally required.

As an adjuvant to the treatment, salt bathing, with frictions by means of rough towels, will be found to do good. The temperature of the bath must be regulated by the vigor of the patient. It is most prudent to commence with one moderately warm, and gradually reduce the temperature to the point which will not be followed by chilliness, or from which the little one will quickly react. When the weather is changeable or cool, the body should be carefully protected by flannel and other clothing.

To prevent curvatures of the bones, particularly in those of the arm or the leg, some benefit may be derived from a light plaster dressing applied with little pressure to the different sections of the limb, not including the articulations. When this is not deemed feasible, the child can be laid upon its back on a mattress, or on a water- or an air-bed fitted to a little wagon, and in this way be drawn about during favorable weather in the open air. As the disease improves and the bones become more firm, the curves are frequently lessened by the action of the muscles, and should this not follow, a great amount of correction can be effected by properly-constructed instruments, and by elastic bands. Suspension by the head for a few minutes twice a day will materially straighten any spinal curvatures which have been formed, and after a few such suspensions the advantage gained can be preserved by a gypsum roller applied to the trunk over a neatly-fitting flannel shirt. (See treatment of Pott's disease, vol. ii.)

The cases of bone curvature requiring drilling and fracture are quite exceptional.

Osteomalacia.

Osteomalacia is the name given to a disease affecting the bones of adults, which is characterized by the disappearance of the lime salts or earthy constituents, and the subsequent softening and even liquefaction of the organic

portion of the osseous tissue. This singular affection is also known under the names of *malacosteon* and *mollities ossium.*

By the older writers, osteomalacia and rickets were regarded as identical, or, at least, very closely allied diseases. Their dissimilarity, both in chemical and in other structural changes, first indicated by Levacher, has been amply confirmed by the observations of Lobstein, and by those of a later date, made by a number of English, German, and French writers.

In osteomalacia the bones are not only soft and flexible, but they are relatively lighter than normal bones. The disease may be confined to a single bone, to one or several points of the same bone, or it may attack the entire skeleton. The vertebræ, ribs, and pelvic pieces are the bones most commonly attacked, whilst those forming the head and face rarely suffer. The deformities which follow, though resembling in many respects those of rickets, yet possess several material points of dissimilarity. For example, the transverse diameters of the pelvis are greatly contracted, and the pubic symphysis rendered very prominent, by the pressure of the thigh-bones, whereas in rickets it is more commonly the antero-posterior dimensions of the pelvis which suffer.

In the latter affection, when the sternum is displaced, it is, as a rule, pushed forward, while in malacosteon it is as likely to be retracted. Charcot has noticed* singular changes wrought in the ungual phalanges of the hand by osteomalacia, these parts of the fingers becoming very flat, and bending unusually far backward, the result, no doubt, of the efforts made by the patient with the terminal phalanges to support or to raise the body while in the sitting posture. When the skeleton has been generally implicated, the most singular distortions and postures have followed, as in the case of the Marquis d'Armagnac, recorded by Duverney, or the still more remarkable one communicated by Morand, that of Elizabeth Querian, afterwards Madame Supiot, who died a victim to the disease in 1752. In this woman the trunk of the body was reduced to twenty-three inches in length; the bones of the upper extremities had become greatly misshapen, and those of the lower extremities, especially the femora, so softened that the feet could be readily placed against the sides of the head.

Causes.—Osteomalacia is fortunately a very rare disease. It is said that the valley of the Rhine furnishes the greatest number of examples of the affection. The causes concerned in its production are very imperfectly understood. Rickets, struma, syphilis, miasmatic emanations,† rheumatism, dampness, and food defective in certain mineral substances, have all been invoked in explanation of the morbid change. In some few instances, as in one given by Dr. Omerod,‡ the disease seems to be hereditary. However little may be known on the subject of causation, there are certain conditions of sex, of age, and of social life which undoubtedly exercise a determining influence.

Sex.—The number of females affected by the disease greatly outnumber the males. In the 47 cases of Beylard, 36 were women and 11 men. Of 131 cases recorded by Litzmann, 120 were females and 11 males. Durham found 132 women and 13 men in an aggregate of 145 cases. That is to say, of the above 323 cases of this disease, 288 were females and 35 males. Holmes§ has not observed so great a disproportion between the sexes as that furnished by the above statistics, though the number on which he bases this statement is too small to weigh against the general statement,—namely, 10 cases, in which 6 were women and 4 men.

Age.—In Beylard's cases, the largest number (20) occurred between fifty and sixty; next in order of frequency, between thirty and forty (17); only 2 under twenty, and 3 after sixty. Of those given by Durham, the greatest number were found between twenty-five and thirty-five years of age.

* Mémoire de l'Académie Royale des Sciences, 1753.
† Jones, British Medical Journal, September, 1859.
‡ New York Medical Record, March, 1869, p. 25.
§ Holmes's System of Surgery, vol. iii. p. 796.

Social state.—The influence of child-bearing also appears to act as an exciting cause, and may explain the predominance of the disease among females. In Beylard's 36 cases, 31 had borne children. In Litzmann's collection of 120, 85 had been mothers. Durham found 91 of the 132 women embraced in his statistics to have been attacked either during or very shortly after pregnancy; and Collineau, who has collected 43 cases of osteomalacia among females, states that 29 of this number had given birth to children.

Food.—The testimony which has been adduced in favor of the causative agency of certain kinds of food in the development of malacosteon, especially aliment poor in the saline constituents of bone, must be regarded as of a negative character, though, independent of experiment, the connection of the disease with the parturient state, in which there is an increased demand for these salts, gives some plausibility to the theory. The examination of a number of bodies of insane persons, made by Dr. Herdner, would seem to imply some connection between mental disease and physical changes in the bones akin to the one under consideration.

PATHOLOGY.—What part is played by inflammation in producing so remarkable a transformation of bone as that present in malacosteon has not been determined. Certain it is that one of the earliest phenomena witnessed is that of increased vascularity of the medullary tissue. The vessels become excessively engorged, and frequently give way, causing apoplectic extravasation of blood-clots, which are found disseminated through the medulla, intermixed with fat and some new cell-elements, the exact import of which is unknown, but the presence of a true infiltration, such as commonly characterizes inflammation, cannot be asserted. This engorgement, at first central in the medullary tissue, and filling its cells with a gelatinous material, moves centrifugally, extending to the outer portions of the cancelli (the cells of which are gradually dilated), and finally passes into the Haversian vessels of the compact structure. Coincident with this vascular disturbance commences the work of decalcification, which, like the first, extends from within outward, the products passing off partly by the kidneys, in the form of oxalate of lime, and forming, in some instances, according to Solly, renal vesical calculi. The saline constituents which impart solidity to the structure are gradually removed, rendering the bone soft and flexible, and leaving only a frame-work of cartilage, which in turn disintegrates and liquefies. As lactic acid has been discovered in the marrow of malacosteon bones, and as this agent is known to have a powerful influence over the lime salts, it is not improbable that to it may be ascribed the disjunction of the organic and inorganic components of the structure. The analysis made by Lehman of four malacosteon bones (two femurs and two ribs) exhibits 24.40 of earthy and 75.60 of animal matter in 100 parts. A number of similar analyses have been made by other chemists, the results varying in each case, but all going to show the lessened amount of the mineral salts as compared with the organic constituents of the bone.

The appearance presented by the medullary tissue—if such it still be—during the progress of these changes will depend much on the particular stage of the affection when the examination is made. At the commencement it may resemble the marrow of young bones, having a reddish or yellow tint, becoming straw-colored, viscid, and gelatinous as the disease advances, or exhibiting a cystic degeneration, the liquid of which may fill up the cavities of the bone or be inclosed in numerous loculi, until finally the entire bone becomes expanded into a mere honey-combed shell. The thin outer lamella of the cortex, depending as it does for its life as well as for its renewal chiefly on the periosteum, will often resist for a long time the malacosteon aggression, though sooner or later this last barrier may yield and the entire structure become a sac of flexible matter.

Changes not unlike those wrought by cancer have been noticed in malacosteon bones, as in the one described by Mr. Hawkins,* which resemblance

* Medico-Chirurgical Transactions, vol. xxiv. p. 45,—Holmes.

has led to a supposition that the two diseases are analogous, if not identical. The chemical and other mutations to which the skeleton is thus subjected, rendering it powerless to resist the weight of the body or the action of the muscles, occasion various curvatures and fractures. The vertebral column is among the first to realize distortion, and especially the lumbar portion, which from its position is compelled to sustain the greatest pressure; the other regions are affected in order from below upward. The curves are increased, the individual vertebræ shrink, and the entire column becomes shorter. The ribs are bent or broken by the muscular contractions concerned in respiration, the lesions occurring, as a rule, contiguous to the tendinous attachments of the posterior serrati, levatores costarum, and the tendons of the erector spinæ muscles, or anteriorly in front of the great serrati and lesser pectoral muscles. The pelvis participates in these changes, undergoing alterations which materially affect the diameters of its cavity, to which allusion has already been made. Under the action of the same degeneration the bones of the extremities and the clavicle become curved or broken, leaving only those of the head and face comparatively free from the general ruin. Notwithstanding the absence, in a great degree, of the mineral salts of the bone, the presence of these materials in the blood, and the tendency of the latter fluid to return them to the bone, are both very evident from the fact that the fractures which occur in the course of the disease undergo repair by the deposition of callus, after the manner adopted by nature in similar accidents of an uncomplicated kind, though neither so rapid, orderly, nor perfect as in the last.

In addition to the structural alterations of the bones, the muscles early undergo certain alterations, characterized by multiplications of the sarcous nuclei, albuminoid and fatty degenerations, and other changes which indicate a pre-existing inflammatory disturbance.

Symptoms.—Among the earliest signs of osteomalacia is the presence of deep-seated, gnawing pains, resembling those of periostitis and caries. The pains are generally located about the pelvis, in the loins, over the chest or limbs, situations corresponding to the regions of the skeleton generally first affected, and are often intermittent, having nocturnal exacerbations, and being increased in severity by dull or damp states of the atmosphere. The patient is easily fatigued, is incapable of any prolonged exercise, and finds it difficult to make a full inspiration. As the bones begin to yield, the footing becomes uncertain and the gait unsteady. From the various deformities or curvatures becoming more and more pronounced, and from the frequent occurrence of fracture, the person becomes exceedingly helpless. The progress of the disease is usually slow, and prone to pauses or interruptions. This is especially so in females, who during gestation experience the greatest suffering, and who after parturition, and during the interval between conceptions, manage to enjoy a reasonable degree of comfort. The disease does not disturb the regularity of menstruation at those times when the function is not interrupted by pregnancy or nursing. The urine is not diminished in quantity, but is often increased, and yields an acid reaction. With regard to the chemical constitution of the renal and other secretions, we are in possession of no observations which are sufficiently numerous or systematic to warrant any expression of opinion. While some writers have alleged a great increase of the different salts of lime in the urine of malacosteon patients, other observers equally competent have been unable to discover any change in this particular, from its ordinary constitutions. The same may be said of the perspiratory and the salivary secretion. Dr. Bence Jones,* in a case in which the softening of the bones was not discovered until after death, noticed in the urine a peculiar albuminoid principle (hydrated deutoxide of albumen), which, unlike ordinary albumen, was readily soluble in boiling water, and the precipitate of which by nitric acid was dissolved by heat, reappearing again on the application of cold.

* Philosophical Transactions, vol. lxvi. p. 55,—Holmes.

The duration of the disease varies from two to six years. The shortest period in which a fatal termination is known to have taken place was in the case mentioned by Schmidt, viz., in three months; and it is not uncommon for patients laboring under the affection to linger along for eight or ten years.

Diagnosis.—In the commencement of malacosteon, when there exist only the initial pains and soreness on pressure and movement, it will be very difficult, if not impossible, to determine the exact nature of the disorder. It may very naturally be referred to cold or rheumatism, but when the bones begin to yield there need be no uncertainty about the nature of the complaint. Though it offers some points of resemblance to rachitis, there are so many dissimilar symptoms that when these are revealed no mistake can be possible. The following peculiarities of the two affections, when contrasted as below, will make this subject clear:

OSTEOMALACIA.	RICKETS.
A disease of adult life.	A disease peculiar to children.
Affects chiefly females.	Affects males and females indifferently.
Softening progressive, rarely becoming arrested.	Softening frequently arrested and patients recover.
Attended with severe pains.	Absence of pain.
Depressions in the occipital bone, or craniotabes.	Without any such depressions.
Absence of epiphyseal swelling.	Epiphyseal swellings.
Fontanelles closed.	Fontanelles, and often sutures, open.

Prognosis.—The disease is almost always fatal, death taking place from exhaustion, from visceral disturbances consequent on the resulting deformities of the surrounding walls of bone, and from those complications which arise from a deformed pelvis, rendering the Cæsarean operation necessary for the delivery of the fœtus. In a few instances patients have been carried off by pneumonia and other inflammatory affections altogether independent of the constitutional disease.

Treatment.—The treatment in cases of osteomalacia must be regulated with a view to sustain the general strength, to alleviate pain, and to guard against the effects of pressure. For the first, tonics, such as quinine, cinchonidia, iron, cod-liver oil, and the phosphates, together with a nutritious diet of milk, eggs, brown bread, fish and other meats, will answer the best purpose, not forgetting at the same time the importance of a dry, healthy location. When the pain becomes aggravated and interferes with sleep, anodynes must be exhibited; and, as a defensive measure against bending and fracturing of the bones, the recumbent position should be maintained on mattresses, supplemented by air-cushions, and, when circumstances will allow, by the employment of the water-bed. Females who suffer from the disease should, as a prophylactic measure, avoid pregnancy.

Fragilitas Ossium.

Fragilitas ossium is a very indefinite term when used to express a specific disease. As an effect of several morbid conditions of the osseous tissue it is not uncommon. From whatever cause it may arise, it consists in an abnormal brittleness of a bone, by which it breaks on the application of the most trifling amount of force. Medical and surgical books abound in extraordinary examples of this kind. The defect is sometimes local, and occasionally affects every bone in the skeleton. In one patient of my own, a female, the fragility appeared to be confined to the ribs, a large number of these having been broken in the course of her life. In a number of cases, generally females, the patella has been in each the seat of several fractures. Professor Gross records the case of an aged woman in whom, in consequence of a fall from a considerable height, there were produced upwards of eighty fractures. The case given by Chaussier, of one hundred and thirteen fractures occurring at different times, is another in point among the many mentioned by different writers. The fragility is sometimes so great tuat the slightest force will cause a bone to

give way. Thus, the accident may be produced by turning in bed, by tripping over the carpet, in the act of gesticulating, and in many other very unexpected ways.

The bones most commonly affected are the patella, femur, ribs, humerus, tibia, and clavicle. Often the brittleness is limited to a portion of a bone, as the neck of the femur or the surgical neck of the humerus.

Causes.—There are various causes which, in consequence of the chemical and physical changes induced by their presence, render the bones of the skeleton fragile. Among these, aside from inflammatory diseases and from rickets and malacosteon, may be mentioned syphilis, gout, rheumatism, cancer, hereditary peculiarities of constitution, old age, and atrophy. The children of syphilitic parents are more liable to suffer in this way than the parents themselves. Bones are often broken even in very gentle attempts to overcome rheumatic anchylosis or the adhesions following a luxation. Twice have I seen the thigh broken, in persons suffering from mammary cancer, by the effort of turning in bed. I attended a child five years of age for a fracture of the tibia and fibula, caused in the usual gambols of play, whose father and grandmother had each been the subject of several similar injuries. A like instance is mentioned by Pauli, of Leipsic.

Fragility of bone is an almost constant attendant on advanced life, in consequence of the fatty degeneration and the atrophy which occur in the skeleton of old persons. The bones of a paralyzed limb, from defective innervation and circulation, undergo similar changes, and possess less power of resistance than those of the sound member.

The pathological appearances of fragile bones differ according to the causes which are concerned in the production of the disease. It may follow from inflammatory infiltration, from decalcification, from fatty degeneration, or it may exist from atrophy without any material disturbance in the relative properties of the organic and inorganic components of the structure. There are no symptoms which declare the commencement of fragilitas ossium, except where the disease has a rachitic or malacosteon origin. The first indication of the vice is perhaps given by the occurrence of a fracture from a slight cause. The urine has been observed to be loaded with the phosphate and carbonate of lime, but, as the presence of these constituents in the secretion may be seen in other very dissimilar affections, it cannot be regarded in itself as diagnostic. When produced by rheumatic or syphilitic causes, severe deep-seated pains may harass the patient.

Treatment.—When the signs of fragility appear in the young, or when there has been a family history of this weakness, much may be done to avoid fractures by the use of precautionary measures. As to internal remedies, they are at best of very doubtful value. Phosphates, cod-liver oil, iron, and mineral acids have been recommended, but, except as agents designed to improve the general health, there is no evidence that they accomplish any good. In the same way a liberal diet and proper hygienic surroundings are important. When the disease is accompanied with severe pain, the iodide of potash and opiates will ameliorate the suffering. If the patient be young, with the growth and vigor of advancing years improvement is not impossible.

Hypertrophy.

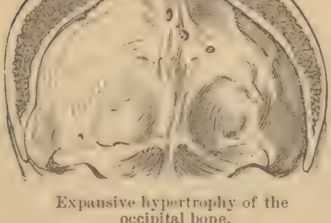
There are two kinds of bone hypertrophy,—the non-inflammatory and the inflammatory. The first is the effect of an increased normal nutrition incited by functional activity. In my possession are two scapulæ taken from the body of a person who had been the subject of hemiplegia. The helpless condition of the diseased side had been supplemented by an increased use of the sound arm and shoulder, and the consequence was that the scapula of the latter had grown to an unusual size, its ridges and processes being strongly developed. The same cause which had necessitated the active exercise of the sound limb had been followed by atrophy of the scapula of the paralyzed

one, the bone being under-sized, very delicate, and white in appearance. The bones of the right arm of the smith, or those of the leg employed by the machinist in driving a pedal lathe, will be found of greater magnitude than those of the companion limb. The disease is usually confined to the bones of the cranium, the femur, and the tibia. Exceptionally it may implicate the entire skeleton, as in the case recorded by Dr. Mears, of this city.* The hypertrophy is frequently one of compensation, the most remarkable examples of which may be seen in the increased thickening of the bones forming the vault of the cranium in cases of brain atrophy from senile and other causes. Of this nature also is the specimen represented in Fig. 894, in which the fibula has become greatly enlarged from being obliged to supplement a defective tibia, which, after a fracture, failed to unite and became atrophied. In the inflammatory variety of hypertrophy the increase may consist in a centric deposition of callus filling up the cancellated tissue, and even the medullary canal, without materially increasing the circumference of the bone. This follows to some extent the repair of all cases of fracture as a temporary condition; but it exists independently of these injuries, as an effect of certain inflammatory affections of bones, and is called sclerosis, a process which has its analogue in the induration of the soft tissues. The inflammation which gives rise to what may be termed expansive and elongated hypertrophy—that is, to enlargement in the thickness and in the length of bones—is rarely of an active type, as may be inferred from the subjective nature of the accompanying phenomena, and is excited by constitutional influences such as attend syphilis, and also in exceptional cases from conditions in some way allied to the puerperal state. When the first form, the expansive, is observed in the bones of the cranium, it may be confined wholly to an increase in the volume of the diploë, the inner and outer tables remaining unaltered (Fig. 895); or it may affect the entire thickness of the bone, obliterating all distinction of layers, and imparting to the piece a grayish-white color and a porous appearance, not unlike the open ligneous fibre seen on making a transverse section of the wood of the grape-vine, or, as Durham has designated it, an appearance similar to dry mortar,—a form of *osteoporosis*. (Fig. 896.) When the disease becomes

FIG. 894.

Supplemental hypertrophy, from a specimen in the museum of the College of Physicians, Philadelphia.

FIG. 895.



Expansive hypertrophy of the occipital bone.

FIG. 896.

Hypertrophy including all the layers of the skull bones.—From a specimen in the museum of the University of Pennsylvania.

located in one of the long bones, as in the femur or the tibia, before the epiphyseal consolidation is accomplished, the limb of the affected side may,

* Transactions of the Philadelphia Pathological Society, 1869.

in consequence of becoming longer than its fellow, produce marked lameness. When the elongation occurs in the tibia, the fibula remaining unaffected and acting like the string of a bow, the diseased bone becomes curved anteriorly. (Fig. 897.)

FIG. 897.

Hypertrophy of the tibia with anterior curvature.—Paget.

CAUSES.—While in many cases of hypertrophy little is known in regard to the nature of the affection, in others the connection of the enlargement with certain inflammatory states of the bone has been well established. In the case of a gentleman who had been struck on the head by a fragment of shell, and whom I trephined in consequence of frequent and aggravated epileptic seizures, the bone had increased to double the usual thickness; and in a second instance of hypertrophy affecting the occipital bone which I had an opportunity of examining, the disease began after a blow received on the back of the head from a slung-shot. Both of these could undoubtedly be referred to an inflammatory origin. Then it is probable that a few cases beginning in inflammation have subsequently continued by an exaggerated nutrition, which has followed in the wake of the first process long after the subsidence of the latter. Among these may be placed, I think, the examples of hypertrophy given by Paget, in which the femur grew too long after recovery from necrosis of that bone. When arising in a syphilitic constitution it is no doubt due to inflammatory changes within the osseous tissue, analogous to those which are concerned in deforming the exterior of a bone with nodes.

DIAGNOSIS.—The only affections with which hypertrophic curvature of the bones can be confounded are rickets and osteomalacia.

From the first it may readily be distinguished by the curvatures in hypertrophy being anterior, while in rickets they are lateral. In rickets, moreover, the bones are shorter than natural.

Osteomalacia is a disease of adults, and is accompanied by general deformity and an exceedingly brittle state of the bones, which will sufficiently distinguish it from hypertrophy.

TREATMENT.—The chief duty of the surgeon consists in providing for the inconveniences which result from the disparity in the length of the limbs in cases of femoral elongation, which, if neglected, is prone to cause a compensatory curve in the spine, or a pes equinus of the foot, the remedy for which is an additional sole placed on the shoe of the normal limb.

When there is reason to suppose that the affection is due to a syphilitic taint, benefit may be derived by exhibiting the iodide of potash either with or without mercury.

Atrophy.

Atrophy, like hypertrophy, has both a non-inflammatory and an inflammatory origin. In the first there is a simple wasting or absorption of the organic and inorganic components of the bone, and in the second there are infiltration, softening, and rarefaction.

Among the first or non-inflammatory causes may be enumerated age, disease, paralysis, and pressure.

The wasting which takes place in advanced life is only the counterpart of a similar change which, as a rule, reigns throughout the body of old persons. Two changes are ever in operation during life, namely, supply and waste. It is the nicely-adjusted balance of these two processes which confers

permanency of form and efficiency of function. In old persons, the chief cause of tissue-decay is diminished functional activity. The enforced rest of age is followed by a less active circulation in the bone, the phosphate of lime begins to disappear, the cancellated tissue becomes rarefied, accompanied by fatty metamorphosis and thinning away of the cortex, the dimensions of the bone are materially lessened, and its weight is lightened. In this way do we account for those degenerations in the head and neck of the femora of old persons, by reason of which fracture is so common.

After the teeth have dropped out or have been drawn, the office of the alveoli being abolished, the process gradually disappears by absorption. A limb rendered powerless by a central lesion, as in paralysis, labors under a twofold disadvantage,—lack of motion and the withdrawal of nerve-power, both of which are inimical to nutrition, and hence the gradual atrophy of the bones of an extremity so stricken.

Pressure not only resists the growth of the skeleton, but is also actively concerned in the removal of the bony tissue. Craniotabes is a conspicuous example of this kind, though the sound bone is by no means exempt from the operation of the same cause. When the pressure is either continuous or intermittent, the absorption begins in that part of the bone which is immediately in contact with the compressing body. Thus, a tumor of the scalp will sometimes hollow out a depression in the bone against which it grows; a growth in the antrum, while it expands the walls of that cavity, will at the same time thin them out until finally they disappear; and an aneurism of the thoracic or the abdominal aorta will, by its repeated strokes against the vertebræ, form for itself a large cavity, which has gradually deepened from without inwards. Such a change results from diminished vascularity, incident to mechanical pressure.

The extent to which the work of absorption may go on is only limited by the bone itself. The late Dr. Norris* has recorded an instance in which the entire humerus, after being twice broken near its middle, was removed in this manner; and in a case of ununited fracture of the same bone which was brought to my notice by a medical man, one-half of the bone had disappeared, and I doubt not, in time, the issue will be the same as that in the case given by Dr. Norris.

Inflammatory atrophy is by no means common. It may occasionally be seen after cases of necrosis or caries in which the repair has been imperfectly accomplished, and in cases of the interstitial absorption of the neck of the thigh-bone which sometimes follows falls or blows over the trochanter major. This last change is an important one from a medico-legal point of view.

No treatment has any power to arrest osseous atrophy, unless the case be one arising from disease not occasioned by circumstances attending, or maladies incident to, advanced life, when, by manipulation and artificial movements, the waste may in some measure be arrested.

Tumors of the bones will be considered under their proper head.

* American Journal of the Medical Sciences, January, 1842.

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END OF VOL. I.

ERRATA.

Page 273, twenty-fourth line from top, read "complicated" instead of "compound."

Under the head of Trephining, on page 305, fifteenth and sixteenth lines, read "by the chisel or lever. The use of the trephine is also allowable."

The trephine in Fig. 216, page 308, should be represented projecting a little over the depression.

Page 920, second line from the bottom of the page, read "ungual" instead of "ungeal."